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THE MATTER OF WATER FILTRATION AT PHILADELPHIA was referred to Mr. John C. Trautwine, Assoc. Am. Soc. C. E., Chief of the Bureau of Water, on Aug. 3, requesting that by Sept. 1, or in just four weeks, he submit plans and estimates for the "filtration of all the water used by the city." Mr. Trautwine submitted his report to Mr. Thos. M. Thompson, Director of Public Works, on Sept. 9, and the report has just been made public. The report first mentions the inadequacy of the time available for its preparation, and states that on that account no general plan can be recommended for adoption. In deference to the wishes of Mr. Thompson and Mayor Warwick the estimates are based mostly upon slow sand filtration, with suggestions for mechanical filtration at one station. Owing to the vast amount of water wasted in Philadelphia, two sets of estimates are submitted, one for water used, and the other for water used and wasted, both in the year 1900, the quantities per capita being 100 and 300 gallons, respectively. The figures for construction and operation are as follows:

Cost of Installation.

	For water used in 1900.	For water used and wasted in 1900.
Filtration plant	$2,398,500	$7,195,500
Real estate	100,000	300,000
Meters, $500,000 to	1,000,000	0
Total incidental to filtration	$3,498,500	$7,495,500
Immediate requirements for other extensions and improvements	1,107,000	5,014,000
Total	$4,605,500*	$12,509,500†

Annual Expense of Operation.‡

Filtration plants	$200,000	$600,000
Meters	90,000	0
Total annual additional expense.	$290,000	$600,000

*This would give an ample supply of filtered water for the entire city in 1900, and a surplus of pumping capacity of about 100%.

†This would furnish sufficient water (filtered) to meet the demands of the year 1900, but without surplus capacity.

‡This, in the case of water used, would undoubtedly be more than covered by the reduction due to restriction of waste.

The report also includes an estimate for the cost of mechanical filters for the whole supply, submitted by the New York Filter Manufacturing Co. These figures were $2,052,387 and $6,149,849, respectively, for water used and for water used and wasted in 1900, the total daily quantities in each case being 130,000,000 and 390,000,000 gallons, as in the estimate for slow sand filtration. In conclusion, Mr. Trautwine strongly urges that no measures be adopted for the filtration of the whole supply until a filter plant large enough to supply a whole district has been built and operated. He recommended the appropriation of $300,000, for the restriction of waste and a filter plant for the Roxborough district, and that experts be appointed to co-operate in the design of the plant. The information given has been taken from an authorized abstract of Mr. Trautwine's report. Unofficial abstracts of the report of Mr. Thompson indicate that he favors the immediate construction of filtration plants to the extent that the money available will allow, recommending slow sand filtration at Lardner's Point, on the Delaware River, and at Belmont, on the Schuylkill River. Regarding the restriction of waste, Mr. Thompson is reported as saying in one place that he is in favor "of increasing our facilities to supply a greater abundance of water," and in another, "the adoption of such legislation as may result in the curtailment of the excessive waste of water."

THE COVERING OF THE FILTER BED connected with the water-works of Lawrence, Mass., has been recommended by the Massachusetts State Board of Health. This is deemed necessary to prevent the formation of ice on the bed and insure the proper working of the filter and the ability to clean it in winter.

PROGRESS ON THE CLEVELAND WATER-WORKS tunnel, described in our issue of Aug. 11, 1898, has been as follows, up to Oct. 1: The steel intake crib has been brought to within 0.11-ft. of a level position, the steel work is nearly finished, ready to begin on the parapet, and the work of filling the crib with stone is in progress. As an additional protection against floating ice a belt of concrete 4 ft. wide and 8 ft. high, 4 ft. above and 4 ft. below the water line, is being placed on the inside of the crib. Shaft No. 3, in which there has been trouble with water, has been sunk to its full depth, and 14 ft. of tunnel driven. After having been shut down several weeks for repairs to the contractor's plant, it was proposed to pump out the shaft early this month and calk leaks preparatory to going on with the headings. From Shaft No. 2 there has been completed 2,024 ft. of tunnel in the East drift and 2,056 in the West. From the shore shaft, or No. 1, no work has been done since the second explosion, last July. The contractors talk of finishing the remaining tunnel between shafts Nos. 1 and 2 entirely from Shaft No. 2, but the matter has not been decided. These facts were obtained by a representative of this journal, while in Cleveland, from Mr. M. W. Kingsley, M. Am. Soc. C. E., Chief Engineer of the work, and Mr. C. F. Schulz, First Assistant Engineer.

THE ABOLITION OF GRADE CROSSINGS in Newton, Mass., has been reported on by Mr. H. D. Woods, City Engineer. The estimated cost of abolishing all such crossings now remaining is $987,000, of which it is stated the city would pay about $100,000.

THE TOTAL DEATHS in the United States Army from May 1 to Sept. 30, inclusive, are reported as follows by the Adjutant-General's office:

	Officers.	Enlisted men.
Killed	23	257
Died of wounds	4	61
Died of disease	80	2,485

This makes an aggregate of 2,910 deaths out of a total force of 274,717 officers and men, or a death-rate of 10.59 per thousand for the five months. We understand that deaths of officers and men on furlough are not included in these totals.

THE LOSS IN THE U. S. NAVY, in the war with Spain, was only 17 men killed and 67 wounded, and of the latter 54 returned to duty. Surgeon-General W. K. Van Reypen, U. S. N., Chief of the Bureau of Medicine and Surgery, has handed in his official report. He shows that the U. S. Navy, before the war commenced, secured competent surgeons from civil life to meet the possible demand for them on auxiliary vessels and commissioned 37 as Assistant Surgeons out of the 2,000 applications received. The Bureau fitted out as a hospital ship the "Solace," a steel vessel of 3,801 tons, a speed of 16 knots, and comfortable accommodations for 200 patients and the medical staff. She was ready to take the wounded at the bombardment of San Juan. The "Solace" made numerous trips to northern ports and went back loaded with all manner of supplies for the sick. The medical officers of the "Solace" first introduced antiseptic surgery at sea. Throughout the report there is evidence of careful and intelligent preparation for all emergencies, by the naval medical staff; and the small percentage of loss of life from wounds and the general good health of the navy is proof of the efficiency with which the medical officers discharged their duties.

CORN-PITH CELLULOSE, for the protection of warships against leakage from shot-holes, was officially tested in Russia, on July 19. The cellulose was furnished by the Marsden Co., of Philadelphia, and was handled by experts of that company. It was packed in a coffer-dam 6 ft. long by 6 ft. deep and 3 ft. thick, and subject to a head of water of 5 ft., and compressed until it weighed 8 lbs. per cu. ft. This dam was then perforated by a 6-in. solid shot striking 20 ins. from the bottom and less than half a pound of cellulose was carried out by the shot. In one-half hour after the water was turned on back of the dam a moist spot appeared on the front, but this was proven to come along the bottom of the packing and not through the shot-hole; in four hours no water came through the shot-hole and only 6 gallons passed under the packing. The test was pronounced a complete success by the Russian naval authorities present, according to the statement of U. S. Consul-General W. R. Halloway, of St. Petersburg. He says it opens up an immense market for Indian-corn pith.

A NEW SYSTEM OF SIGNALING at night has been tested on the steamer "Kaiser Wilhelm der Grosse," at her pier in Hoboken, the signals being read from the pier of the American Line in New York, over two miles distant. The system consists in throwing the letters of the international code, one at a time, on a screen by means of a reflecting lamp. The inventor proposes to use instead of a fixed screen, on which to display his signals, a rotating canvas-covered wind wheel, or screw, which will not flap in the wind as a sheet would do. The letters used in the test were 15 ft. high.

THE MANCHESTER SHIP CANAL was designed for ships of not over 3,000 tons and drawing 22 ft. of water. The steady increase in the capacity and draft of ocean steamers is now giving trouble for the canal owners, as the present channel will not accommodate even the later class of ocean tramps. As a direct trade in cotton with American ports was one of the chief objects of the original promotors of the canal, the deficient depth of channel presents a grave problem for solution. More docks and warehouses are also needed for handling and storing the cotton; and the want of these taken with the comparatively shallow channel, are hindering the growth of the canal business. In the first half of 1898 the increase in canal revenue was about $45,000, as compared with an increase of $80,000 in the corresponding half of 1897, and $90,000 in 1896.

THE DRAINAGE OF THE CALUMET DISTRICT lying to the south of the main business section of Chicago, Ill., and comprising South Chicago and the neighboring territory, is discussed in a special report recently made to Mr. L. E. McGann, Commissioner of Public Works, by a commission of engineers appointed to investigate the subject. At present the Calumet River receives a large amount of Chicago sewage, which in time of high water is swept out into Lake Michigan to pollute the water supply. To remedy this the report recommends constructing a canal from the river to a connection with the Drainage Canal at the Sag, which will divert the flow from the lake westward. The canal recommended is to have a capacity of 50,000 cu. ft. per minute, and is estimated to cost $1,621,000.

THE CHANGE OF GAGE from 3 ft. to 4 ft. 8½ ins. on the Port Austin division of the Flint & Pere Marquette R. R. was effected on July 17. This division extends from Port Huron to Grindstone City, Mich., a distance of 92 miles, and the work was done by 274 men during a long, hot day. A considerable amount of preparatory work was done in advance to enable the change to be made in one day. This consisted in planing the ties by machinery attached to a car, the ties being planed for a space wide enough to receive the rail and spike. This was done before any spikes were driven. Then, by means of suitable gages, all the outer spikes were set for the new position of the rail, and were driven nearly home. On July 16 a large number of the old spikes were drawn. The old rails were used almost entirely, joints being unbolted at suitable intervals to facilitate the sliding of a length of rails to the new line of spikes. The rails were then spiked on the inside at the joints, centers and quarters, to make the track safe for the passage of trains. The railway company had been putting standard ties in the track for two or three years, about one-fourth of the ties being new and put in during May and June. The rails weigh from 35 to 45 lbs. per yd., and the traffic is light. Trains passed over the line on July 18, the only delay being for three hours on one section, where a green man blundered and failed to notify the division roadmaster in time to receive aid. Mr. Wm. B. Sears, M. Am. Soc. C. E., is Consulting Engineer; Mr. Geo. M. Brown, Chief Engineer, and Mr. E. Treadwell, General Roadmaster.

ELECTRIC LIGHTING FROM THE CAR AXLE has been adopted on the limited train of the Atchison, Topeka & Santa Fe R. R., running between Chicago, Ill., and Los Angeles, Cal., a distance of 2,209 miles. The aggregate candle power generated will be about 4,928 candle power, including, besides the regular train lights, lamps in all berths and the locomotive headlight.

A FAST RUN was made by a special train on the Lehigh Valley Ry. on Oct. 9. From Buffalo, N. Y., to Rochester Junction, 69 miles, the time was 67 mins., and the first 105 miles were covered in 102 mins. The run to Ithaca, 148 miles, was made in 2 hrs. 46 mins., including 12 mins. lost in stops.

THE CHINESE NORTHERN RAILWAY, as built by the state and open for traffic, includes the Tiensin-Tonghu-Chunghouso line, 214 miles long, and the Tiensin-Pekin line, 80 miles long. These roads are said to be the cheapest yet built in China, and cost $25,500 per mile, not including large bridges, but including the heavy fees demanded by Chinese officials. On the Pekin section the only heavy work is the lattice bridge over the Peiho River, 984 ft. long. There are heavy embankments and many small bridges. The roadway and station buildings on these lines are American in type; ballast is very scarce and not used at all on some sections, and the American pine ties cost 81 cts. each. The rails are of Belgian make and the locomotives were made in England and America; the rest of the rolling stock was built in the shops at Tongshaw. The line is single track, but roadbed and bridges are built for double track. The Viceroy Chi Li is the head of the railway department, and excepting a few Europeans at the head of each secondary department the staff is Chinese. These notes are taken from an article in the Proceedings of the Austrian Society of Engineers and Architects for 1898.

THE MERRITTON TORNADO.

By Orrin E. Dunlap.

One of the most severe tornadoes that has ever been recorded east of the Mississippi Valley swept through St. Catharines and Merritton, Ont., and Niagara Falls and the Tonawandas, N. Y., on the afternoon of Monday, Sept 26. The destruction of life and property during the brief period while the storm lasted was something awful, and while pictures and words may in part describe the result in this storm-swept territory, they cannot give to the reader a full realization of the terrible nature of the disaster. The people living in the vicinity of the storm of September 26 had read of the destruction done by tornadoes on the Western prairies, but it was only when they themselves found the storm upon them that they realized the power and terror of such a visitation. With loved ones dead or injured, and with their homes swept out of existence, the full truth came home to them.

The early part of the afternoon of Sept. 26 was beautifully bright until after 3 o'clock, when a dark, peculiar-looking cloud made its appearance in the northwest sky. Many noticed it, and watched it, and remarked its unusual appearance. This strange-looking cloud grew in size, and distant thunder announced an approaching storm. The cloud changed its shape; gathered itself like a balloon, and then was seen to send out two funnel-shaped tails earthward. One of these tails touched below Welland Ave., between Lake and George Sts., in the city of St. Catharines, Ont., and traveled in a direct line from this point to the southerly limit of the city. Its course was marked by ruin. The drill shed was practically demolished, the western arch being blown in on the gun sheds, breaking them in, and the roof of the hall being carried away. The cloud appeared to rise and fall; in some places destroying houses and barns, unroofing others and carrying away chimneys. Trees were uprooted and tossed about like paper, and the roads were rendered impassable.

It was the village of Merritton, Ont., that suffered most from the cyclone, however, for there it struck with greatest fury. About the first building it struck was the Lincoln paper mill, and it is evident from the wreck it made here that its force was fresh. The buildings were most substantial, of heavy stone and brick construction, but after the storm had passed over them they presented the appearance of a shell-riddled fortress. Roofs and parts of the wall were carried away, as shown in the photograph, but the tall brick chimney withstood the storm. The rain that followed the wind damaged the stock and the interior of the buildings, as well as some of the machines. There were 80 employees at work when the storm struck the mill. One girl was killed outright, and many were injured. Cars on the mill siding were picked up and dropped into the canal. Two men at work loading pulp into a car from a wagon were swept into the water, but were rescued. The wagon was wrecked and the horses were killed. Parts of the mill were carried long distances.

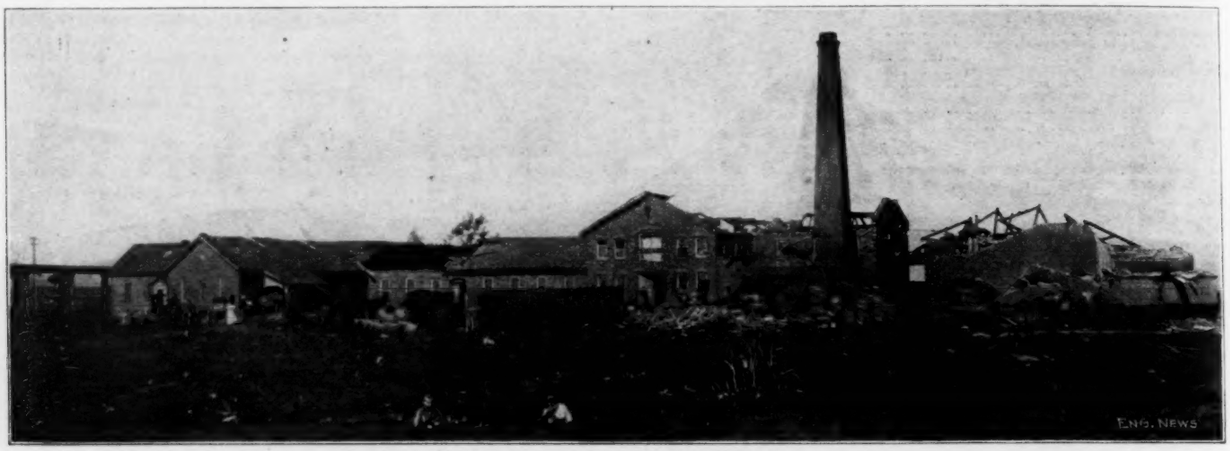
The destruction in and about the public school house was remarkable. When the teacher saw the storm approaching she gathered her little pupils to the number of 40 in the southwest corner of the room. The wind struck the building, and in an instant it was a mass of debris. The children were almost buried, but, after all were taken out, it was found that only one was killed. The school was located on a street running east and west, and next to it on the west was Orange Hall, a frame structure. West of Orange Hall stood the residence of James Bradley, and across the street, directly opposite it, stood the new residence of R. Thompson. The storm first caught the Thompson house, carried it across the street against the Bradley house, which it struck with great force. The two dwellings were then carried onward under the storm's power against Orange Hall, which was in turn swept against the school house. At this point the force of the cyclone seemed to be at its highest. One woman was killed in the wreck of the Bradley house. The Willson carbide plant was damaged, as were also the power houses.

The Presbyterian Church was razed to the ground. A person unacquainted with the conditions before the storm would not have known a building once occupied the site. John Hogan's house, a frame structure, was picked up and tossed against the brick dwelling of Samuel Smith, both being badly wrecked, as shown in one of the photographs reproduced herewith.

In one instance a man was blown out of his buggy. In another case a child was blown from its mother's arms and killed. In several instances boards were driven into the ground, and in one place the ground had the appearance of having been plowed.

After leaving Merritton the cloud seemed to divide, one end rushing over Niagara Falls and the other southward to Tonawanda. At Niagara Falls a severe hailstorm occurred, some of the hailstones weighing 2 oz. and measuring from 7 to 9 ins. in circumstance.

In Tonawanda the scenes at Merritton were repeated, though the force of the storm was not so great. Houses were leveled to the ground, and in one instance a barn was carried 300 ft. Piles of timbers represented what before the storm were three dwellings. In Tonawanda it was also noticeable that the storm jumped about, striking here and there. One strange fact in connection with the storm is that near Merritton there is a highway called Hurricane Road. It is said on good authority that many years ago the locality was visited by a storm which swept a path through the woods, which was continued as a road and given the name Hurricane Road.



WRECK OF THE LINCOLN PAPER MILLS, MERRITTON, ONT.

The Presbyterian Church.

Residence of Samuel Smith.

SCENES IN MERRITTON, ONT., AFTER THE TORNADO OF SEPT. 26, 1898.

THE WORK OF THE ENGINEERS IN THE SANTIAGO CAMPAIGN.

By Eduardo J. Chibas, Assoc. M. Am. Soc. C. E., late Assistant Engineer to the Chief Engineer of the Fifth Army Corps.

(With maps showing position of troops at Santiago.)

The echo of the heavy cannonading from our war ships—which from early dawn had taken their position in front of Daiquiri—had hardly died away, and clouds of smoke from the bombardment were still hanging here and there over the landscape, when the advance guard of the Fifth Army Corps landed on Cuban soil on June 22 without any opposition from the enemy. Among the transports near shore waiting for orders to unload her troops was the steamship "Alamo," with the Fifth Army Corps' Battalion of Engineers, which was composed of two companies of the U. S. Engineer Corps of the regular army —Company C and Company E, of 100 men each. The latter company started from West Point for Tampa on April 30, and the former went from Willett's Point on May 14. Both companies were organized into a battalion in Tampa, under the command of Capt. Jas. L. Lusk, who was relieved before the sailing of the expedition by Capt. Edward Burr, afterwards Lieut.-Colonel of the Second Volunteer Regiment of Engineers. The officers of Company E were Capt. Edward Burr, First-Lieut. E. E. Winslow, now Captain, and Second-Lieutenants H. B. Ferguson and L. Brown. The officers of Company C were Capt. G. D. Fitch, afterwards Major of Volunteer Engineers, Lieut. T. H. Rees, now Captain, and Second-Lieutenants G. M. Hoffman and S. A. Cheney.

On board the "Alamo" were stowed a large amount of square timber of various sizes, 12 pontoons and 15 completed trestles, susceptible of adjustment to any height from 3 to 12 ft. for military bridges; and all the tools and material that any possible emergency might have called into requisition. All the contingencies that might arise had been considered in Tampa, before sailing, and under the personal supervision of Brigadier-General William Ludlow, Chief Engineer of the Army in the field, all the necessary material had been provided. Through his efforts also, many photographs of the Spanish blockhouses and forts had been secured.

The work performed by the engineers in the Santiago campaign may be subdivided into "Reconnoissance," "Piers," and "Road and Bridge Work."

Reconnoissance.

On the morning of June 22, shortly after the first troops had landed, Lieutenants G. M. Hoffman and S. A. Cheney, with four men each, were detached from the Engineer Corps for reconnoissance work under Lieut.-Colonel Geo. McC. Derby, Chief Engineer Fifth Army Corps. They followed close to the advance, taking topography and mapping roads and foot-paths, noting their condition with reference to the transportation of artillery and supplies. They reached the Siboney landing, six miles away, on the next day. The two parties had kept separate, doing work along different roads They reported every evening to the Chief Engineer's office at headquarters—which for the first week was kept on board the steamer "Seguranca," that lay first in Daiquiri and then in Siboney Bay. After the troops passed beyond Las Guasimas, three miles from Siboney on the road to Santiago, where the first skirmish of the war was fought by the Cavalry Division, on June 24, four line officers were added to the reconnoissance party under orders of Major William D. Beach, Division Engineer of the Cavalry Division, through whom they reported to Lieut.-Colonel Derby, Chief Engineer of the Fifth Army Corps. These line officers were Lieut. Guy H. B. Smith and Lieut. D. P. Cordray, of the Infantry, and Lieutenants G. P. White and M. A. Batson, of the Cavalry. After July 3 they reported direct to the Chief Engineer. During the six days of rest and preparation that followed the first battle, and while the troops were camped on either side of the road to Santiago, the reconnoissance party kept constantly at work, very often venturing considerably beyond our outposts and going into the very heart of the enemy's country. The quiet and unostentatious manner in which the work was performed failed to bring it into general notice, and very little has been known by outsiders of the many risks incurred by individual members of the party, and of the commendable and valuable services rendered by them. After looking back over the excellent work accomplished by that small number of men, the only regret is that a much larger party was not placed in the field so that it could have covered the whole country around Santiago before July 1. The information we started with was very meager, as the Spanish government has never made a topographical map of Cuba, and the maps we had for reference showed merely a general outline without topographical features.

On June 27, when the American outposts were located at La Redonda, near where General Shafter established his headquarters three days later, and the Cuban outposts were a mile farther on the road to Santiago at El Poso, Lieut.-Colonel Derby and Lieut. Hoffman pushed the reconnoissance work half a mile beyond on the same road.

On June 28, Lieut. Hoffman went three-quarters of a mile beyond the outposts on the road to Caney, and Lieutenants Batson and Smith, from another direction, approached within less than a mile of the forts around that village.

The writer, on that morning, was ordered to measure a base line and make triangulations at the front to find distances to the City of Santiago, and to locate the prominent points of the surrounding topography. The positions we were able to secure on the hills near our outposts were not advantageous enough for the purposes intended; and on the next day, after having secured an additional force through Major Beach, Engineer of the Cavalry Division, we ventured with Lieut. Batson to within less than a mile of Caney and close to the road connecting it with Santiago, Without the use of field glasses we could see the Spanish sentinels pacing back and forth in front of some of their block-houses. The other members of our party, on that day, were Mr. E. M. Bane, official photographer, one sergeant and two Cuban privates, and one sergeant and five privates of the Ninth Dismounted Cavalry. A peculiar incident of the day was that, without firing a shot we returned to our lines after our work had been performed, with ten prisoners and a horse, captured by our small force. It is fair to explain, however, that they were not soldiers, but civilians, who claimed they had come out of the city to get mangoes and other fruits, and were on their way back to Santiago when we detained them. From them we obtained information as to the number of Spanish troops in Santiago, their condition and the nature of the barbed-wire entanglement around the city. On that same day, Lieut.-Colonel Derby and Lieut. Hoffman had gone scouting with a detachment of six Cubans beyond El Poso and almost to the San Juan River crossing. Later on, they proceeded to Marianage, which the Spaniards had evacuated the day before, and climbing a tree they observed the Spanish position on San Juan hill. On June 30, Lieut. Cheney had completed his reconnoissance along the coast line, and venturing within sight of the Spanish sentinels of Aguadores, reconnoitered their strong position. On that same day Lieut.-Colonel Derby continued reconnoitering the country towards San Juan and went again far beyond our outposts.

On July 1, Lieut.-Colonel Derby, Chief Engineer, and Lieut. Maxfield, of the Signal Corps, made their balloon ascension, which has been so much criticised. The opponents of the balloon claim that its presence at the front betrayed the position of the troops, and that the deadly fire poured upon it by the Spaniards was the cause of unnecessary casualties. On the other hand, the observers in the balloon, who certainly deserve credit for their unflinching valor while exposed to a most severe fire, argue that their discovery of the trail running parallel and to the left of the main road, through which General Kent swung his division as soon as Colonel Derby notified him of its existence, saved many lives by relieving the congestion of the main road through which the troops had been advancing. The results proved, however, that the usefulness of the balloon in warfare must be confined to the rear, or far enough from the enemy to insure it a fair chance of escape from the fire that will be directed against it, while it must be kept far enough from the main body of the troops to prevent the spent bullets from causing losses that might be avoided.

While the fighting was going on, nearly all the officers attached to the reconnaissance party were out with the troops at either Caney or San Juan in the line of fire, noting the position of the different regiments and brigades.

The instruments used in the reconnaissance work were the prismatic compass, cavalry sketching case, and often a hand level. The distances were estimated by pacing. The average daily distance covered by each individual varied, according to the nature of the country and the width of the belt sketched, from one to ten miles. The different parties reported every evening to the office of the Chief Engineer where the works were compiled, fitted together and added to the map of the previous day. A tracing was made, and then blue-prints were issued to the commanders of divisions, brigades and batteries, and other officers as far as the available number would permit. The first blue-print issued in the field was on July 3, and they continued to be issued from that time on nearly every other day, showing all additional information and changes in the position of the troops.

The Chief Engineer's office was moved from the "Seguranca" to headquarters in the field, on June 30; but soon after the capture of San Juan, the office was moved to San Juan hill, just behind our intrenchments for convenience in receiving the daily reports. The mapping and all the field office work was performed by Lieut. Geo. M. Hoffman, of the Corps of Engineers, and the writer, or by either one of them when the other was in the field. Mr. R. S. Porro had charge of the compiling on board the "Seguranca," and continued attached to the office of the Engineer Corps till July 8, when he was transferred to another branch of the service.

The blue-printing was done by means of an improvised field outfit, as the glass of the blue-printing frame was broken while being unloaded at Siboney, and we were unable to secure another one of the same size to replace it. We were fortunate enough, however, to find two pieces of window-glass about 24 × 30 ins. each. Our improvised frame consisted of the cover of one of the packing boxes around headquarters, over which was stretched a blanket folded to make three or four thicknesses. The blue-print paper and the tracing were unrolled, placed on the blanket and kept in contact by the weight of the two pieces of glass resting on it. For a tray for washing the blue-prints, we used a rubber blanket.

The trenches in the Santiago campaign were not laid out by the engineers, but were dug on the nights of July 1 and 2 by the troops of the line, under the direction of their own officers. After the capture of San Juan hill, however, a line officer from each brigade was appointed as Brigade Engineer, under the direct orders from Lieut.-Colonel Geo. McC. Derby, Chief Engineer, and his duty was to look after the trenches and to report daily to the Chief Engineer's office, through one of the members of the reconnaissance party, the changes in his own line of intrenchments, or any changes or extensions he might have observed in the enemy's positions. Some of the trenches that were hastily thrown up during the nights of the first and second of July, were improved later on by orders of the Chief Engineer, and a few had to be changed so as to place them on the military crest, that is, the point from which the defender can sweep with his fire the whole line over which the enemy must advance.

Piers.

On the morning of the first landing at Daiquiri, the engineer battalion was ordered to put ashore a large quantity of intrenchment tools, which were afterwards distributed to the troops of the line; also pontoon material and sufficient lumber to repair the small pier that had been partially burned by the fire started by the Spanish forces as they evacuated the place in the early morning. The damage had been mostly confined to the approaches, and before midnight the repairing was ended. On the next day the main portion of the engineer battalion, under the direction of Brigadier General William Ludlow, was ordered to proceed on the "Alamo" to Aserradero, twenty

miles west of Santiago, to build a temporary pier to facilitate the embarkation of the Cuban forces, under General Calixto Garcia, which were to be transferred to the eastward to co-operate with the American forces. The wharf built at Aserradero consisted of two rows of piles of 5 × 5-in. timber driven by a heavy wooden maul 8 ft. apart longitudinally, and 4 ft. between the rows. The caps were spiked to the side of the pile, to do away with the labor of leveling and cutting them off, and on them rested the flooring of three or four planks.

On June 25, the 3,000 Cuban troops were transferred from the landing at Aserradero, to the three transports, about a mile away, by means of twelve large ship-boats and two navy launches. On the next morning we arrived at Siboney, and the battalion was immediately ordered to proceed to the building of a boat landing at that place. Before dark the work had been completed. The landing consisted of a crib 7 × 7 ft., sunk in C ft. of water, and connected with the shore by an approach 45 ft. long. On that day Brig. Gen. Wm. Ludlow, now Major Gen. U. S. Vol., was detached from the Engineer Corps and given active command of troops in the field; the 1st Brigade of the 2d Division. A portion of the battalion was detailed to begin work on a much larger pier from June 27 to July 1, when the whole battalion was ordered to the front and did not return to Siboney to resume its work till July 5. This pier consisted of three cribs. The first one was 10 ft. square, built of 5 × 12-in. timber, and sunk 30 ft. from the shore in three or four ft. of water. This portion of the approaches was finished about July 1, and began to be used shortly afterwards. The next two cribs, one of which was partially built by the 33d Volunteer Michigan Regiment while the battalion was at the front, were built of 12 × 12-in. timber. They measured 30 ft. deep and 10 ft. wide, and were sunk in 6 and 10 ft. of water, respectively. The spans between the cribs were 15 ft., making the total length of the pier about 130 ft. It was completed on July 12 after many difficulties, due to the heavy surf constantly beating aginst the shore, had been encountered and overcome.

Road and Bridge Work.

The portion of the battalion which was not detailed for the pier construction worked on the road from June 27 to July 1, when both sections were combined, and, as before stated, were ordered to the front. On July 2 the whole battalion worked all day under fire, improving the road near the crossings of the San Juan and Aquadores Rivers, and rendering those fords passable by wagons. On the next day, July 3, the battalion was marched to Sevilla, and on that day and the succeeding one they worked on the road from there to Siboney, where they went to resume the pier work. At that time Lieut. Brown was detached from the battalion and placed in charge of road repairing. Under his orders he was authorized to draw details of two battalions, or about 600 men, from Division Commanders. These details were generally taken from the volunteer regiments, and many men from the 71st New York were assigned to this work. These men made wide clearings on both sides of the road to allow the sun's rays to penetrate and dry the road beds. They corduroyed the swampy portions, improved the drainage, and opened up new roads on either side of the old road, along portions which had been rendered impassable, and extended them so that all portions of the line along which the besieging army was located could be reached by pack mules or wagons. These men also built some bridges and culverts, using such material as was at hand, which was often bad and difficult to procure. Lumber from the landing could not be had on account of lack of transportation.

After the surrender the Battalion of Engineers continued at work until August 16. From July 19 to July 22 they repaired the Aquadores Railroad bridge, one of whose piers and the two spans resting on it had been blown up by the Spaniards. The completion of this work allowed the trains to run from Siboney to Santiago Harbor. Later they repaired portions of the railway from Santiago to San Louis that had been partly destroyed; rebuilt about 300 ft. of a high trestle over Purgatorio Creek, which had been partially burned, and a smaller bridge near Boniato that had also been damaged.

General Remarks.

The Engineer Corps has been widely criticised for not doing work that they were expected to do during the Santiago campaign; but the critics certainly ignore the difficulties under which the Battalion had to labor, not difficulties of nature, which they were fully able and prepared to meet, but difficulties arising from the peculiar manner in which the campaign was conducted. Had the Engineers been furnished with two or three wagons to transport to the front some of the material that was safely stowed in the hold of the S. S. "Alamo" while she rode on the waves in front or Siboney, they could have bridged every single ford in a short time. They could have improved many portions of the road, and its carrying capacity would have been greatly increased. But the Engineers were dependent on other Departments for transportation which they could not secure. They had three wagons for their own use while camping in Port Tampa, and although, I understand, they asked to be allowed to take them with them to Cuba, their request was refused.

The Battalion of Engineers is equipped and drilled as Infantry. The enlisted men in it are trained and drilled as infantrymen, and besides have special drills in building pontoons and military bridges; in laying out and building fortifications; in sapping and mining; in planting and operating submarine mines, etc., and although they accomplished a great deal at Santiago with the means at their command, they were certainly fit to have performed a much greater service than they were given a chance to perform.

In conclusion, it may not be out of place to refer to what was one of the most impressive lessons of the campaign, to every intelligent observer, that our troops were under a great disadvantage on account of their use of black powder. Whenever our cannons and small arms poured forth their shots such a dense cloud of smoke hung around them as to furnish an excellent target for the enemy. On the other hand, when the Spaniards fired it was almost impossible to detect their position, and it was only after considerable watching on our part that their artillery could be located at all.

POPULAR ERRORS ABOUT WATER METERS.*

By John C. Trautwine, Jr.†

The water-works of Philadelphia are pumping more than twice as much water as would furnish to all its people a lavishly bountiful supply at good pressures; yet from all sides come well-founded complaints of beggarly supply and low pressure. The Bureau of Water appeals in vain, year after year, for millions of dollars for new pumps and new mains, and private companies improve the opportunity by suggesting the expenditure of many more millions for prodigious facilities which the city does not need.

The reason is not far to seek. It is perfectly well known that more than half of all the water pumped is wasted, flowing off into the sewers without benefiting even those who waste it—or the sewers. If the waste, or even the major part of it, were stopped, the capacity of our works would be practically doubled, and there would be plenty of water for all. The cost of installation of filter plants, or that of bringing water from a distance, would be cut in two. Even without the adoption of means for purifying the water, the quality of that furnished would at once improve, for pumping could then be stopped during seasons of muddy or coal-polluted water, and the water in the reservoirs would have longer time for sedimentation.

The experience of other places leaves no doubt whatever that the proper use of the water-meter is a radical cure for the evil of waste, and the only one. In other words, upon the meter depends the salvation of our city's water supply. It is therefore most unfortunate that, through ignorance of the facts of the case, the public seems to be standing in its own light by a reluctance to sanction the increased use of meters.

Many of our people appear to be under the impression: (1) That the proposed use of meters in dwellings is intended to restrict the use of water. (2) That the charge for water by meter is excessive. (3) That the waste is exaggerated. (4) That the wasted water helps to cleanse the sewers.

To correct the first error it ought to suffice to say that it is not desired to charge by meter for water used in families. In the first place, it is not proposed to apply the meter to all dwellings, but to those only where outrageous waste is found to be going on.

In the second place, every metered supply, however little the meter shows, pays a minimum charge, established for the express purpose of discouraging economy in the use of water, and in most cases the consumer will have drawn all the water he can possibly use and enjoy, and will have done a fair amount of wasting besides, long before the meter reading equals this minimum charge. The meter thus charges only for water wasted (and not for all of that), not for water used.

There is therefore, as a rule, no inducement to be even careful in the use of water from a metered dwelling-house supply, and this is as it should be. Otherwise undue economy might lead to filth and disease. Gas may properly be so charged for as to induce care in its use, but this is not the case with water. It is better to have a gallon of water wasted than to discourage the proper use of a pint.

The present meter rate (after the minimum charge has been exceeded) is 30 cts. per 1,000 cu. ft., or about 4 cts. per 1,000 gallons, or 1 ct. per 2,000 pints, or 1 ct. per ton. One cent's worth of water would supply from five to ten liberal baths, even if it were proposed to charge by meter for water used for baths in dwellings, or for other domestic purposes.

My bath-room faucet recently began leaking, and I placed the stopper in the tub, in order to measure the loss. The faucet was merely trickling, yet a measurement showed that it was passing about 70 gallons per day. Even so trifling a leak, if it existed in each dwelling-house in the city, would amount to 6% of our total consumption, and would require an engine pumping 20,000,000 gallons a day to supply it; and it is notorious that thousands of houses have numerous leaks, in comparison with which the one in question is insignificant.

An investigation of the consumption of the district bounded by Broad, Seventh, Chestnut and Spruce Sts. showed that 63% of the water furnished to that district was wasted, and by only 17% of the population, the other 83% paying for the wasted water.

A similar examination of a district consisting of two intermediate streets in the northwestern section of the city, where 142 seven-room houses built in 1893 were inspected, gave the following results:

Number of inhabitants	539
Number of appliances	782
Number of appliances leaking slightly	22
Number of appliances turned on continually	32
Average consumption per capita per day, gallons	222
Water consumed during 24 hours, gallons	119,800
Water used, gallons	16,120
Water wasted, gallons	103,680

In other words, of the 222 gallons per head per day consumed, 30 gallons were used and the other 192 gallons wasted.

The only hardship inflicted, even upon those wasteful consumers whose supplies should be metered, would be that of seeing that their plumbing was in good order, and that no considerable quantity of water ran to absolute waste. In short, in order to keep their bills within bounds, they must take care to use most of what they draw.

As regards hardship to manufacturers, it is to be hoped that no Philadelphia manufacturer is in such straits that he would find it a hardship to pay one cent per ton (or but little more than bare cost) for the water supplied to him by the city; but, if it is considered advisable to give water to any or to all manufacturers at less than cost, the city can do this as well with meters as without them. The meter does not fix the rate. It simply substitutes payment by the ton in place of payment by the year. It encourages and rewards care, where the present method puts a premium on the vice of prodigality.

It is a mistake to suppose that wasted water aids in keeping our sewers clean. This water flows through the sewers with too little velocity to accomplish any good in this respect; but the use of meters would render the supply (with our present means) so ample that water could easily be spared for proper flushing of the sewers by jets introduced at high velocities.

I quote as follows, from correspondence and from publications, respecting the experience of other towns:

Atlanta, Ga.—There never was a better illustration of the duty so constantly pressing upon municipal authorities to save and protect the unthinking public against themselves and against the consequences of their own want of knowledge as in this instance. The reform was met by a storm of protests, and so great was the opposition that nearly 400 consumers ordered the water cut off. Soon, however, finding that the pressure and service was so greatly improved and the rates with meters really less than they were without, they all came trooping back, admitting their error and full of thanks and praises.

It was a fight and a sharp one at first, when we put in the meters and filters. Such, however, has been the effect of experience and education, with demonstration of success, that now I make bold to say it would not be merely a fight, but a revolution, if we attempted to abolish meters and filters.

In 1885, with about 2,000 consumers, we pumped about the same amount of water per day as we now do in 1898 with over 6,000 consumers. Our experience is that, with a minimum rate, consumers use nearly the full amount of water allowed them. The sanitary conditions of our city has not suffered by reason of scarcity of use of water.

We had been pumping 6,000,000 gallons per day, but

*Abstract of a paper presented to the Engineers' Club of Philadelphia, Oct. 1, 1898.

†Chief of Bureau of Water, Philadelphia, Pa.

when meters were put in the daily pumpage immediately fell to 1,250,000 gallons, and the pressure rose to such an extent that we could throw ten or more streams from the street hydrants over the tallest buildings without using the fire engines at all.

It was the adoption of meters that made it possible to filter the total supply.

Atlantic City, N. J.—One leaky hopper closet (or one that is allowed to run continuously) in some small property that paid perhaps $6 or $8 per year on the assessed rate will waste water enough to supply half a dozen fine residences and sprinkle an acre or two of lawns besides. In cheap houses, or where there is cheap plumbing, by letting the water run to prevent freezing in cold weather, enough is wasted to furnish baths galore to the whole population.

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The per capita pumpage has been reduced from a maximum of 200 gallons per day to about 75 gallons per day.

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Richmond, Va.—At the commencement of this year we had about 1,400 meters in use. I have, so far, set about 500 meters this year, with the result, taken with those previously placed, that the pressure has increased five pounds at the high points, enabling many consumers who had no water on their second floors during the hours of the day to use water on those floors. Our pumpage has been decreased about 25% from what it was four years ago, and we have a larger number of consumers.

Harrisburg, Pa.—We overcame popular objection by teaching people that the only objectors to meters were those who wanted to get water without paying for it. You know, of course, that more than half of your pumping plant would be idle if you supplied water equitably by meters.

(Besides the opinions quoted, the paper contained others, all in favor of meters, from Utica and Poughkeepsie, N. Y.; Providence, R. I.; Milwaukee, Wis., and Lexington, Ky.—Ed.)

STANDARD POLING CAR; PENNSYLVANIA R. R.

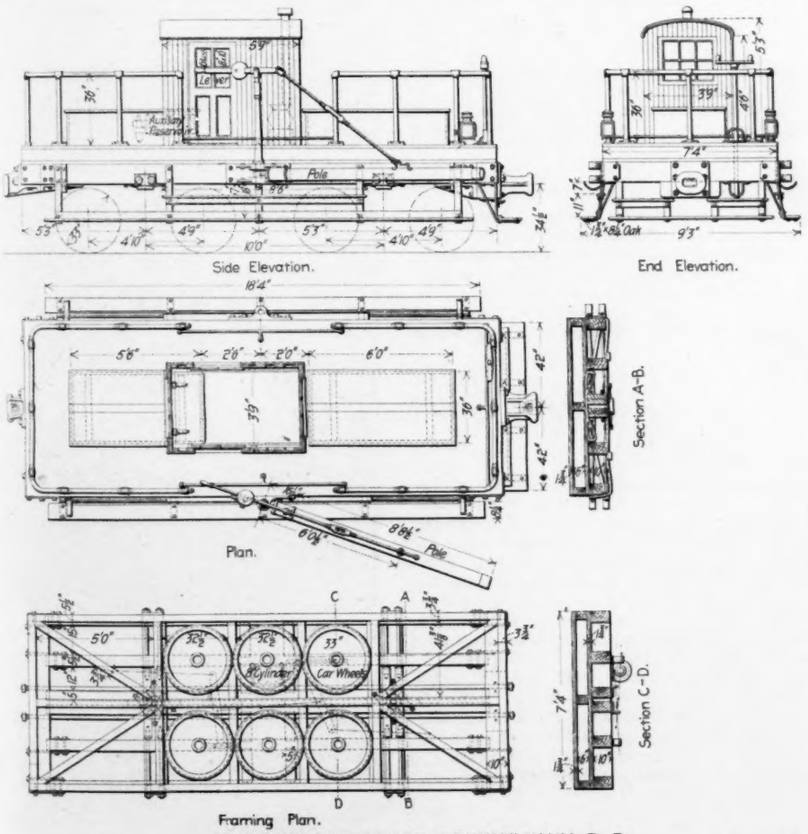
For the handling of cars in railway freight yards, in making drilling movements, two different systems are in general use. In the first, each car or cut of cars is hauled or pushed direct by a switch engine on the same track as the cars. In the second, the cars are pushed by means of a horizontal pole seated in a socket on a switch engine or poling car running to and fro on a track parallel with that on which the cars move in passing to the classification tracks. Operating the pole from the locomotive is usually more or less inconvenient and unsatisfactory, especially in a busy yard, and for such yards poling cars are in many ways preferable. The car is, of course, attached to a switch engine, and runs to and fro on the poling track. One great advantage of the poling system is the rapidity with which the work can be done, there being no time lost in coupling or uncoupling the switch engine, while there is of course far less chance of injury to the yard men than when such frequent coupling and uncoupling movements have to be made.

The accompanying cut represents the latest type of poling car in use on the Pennsylvania R. R. We are indebted to Mr. F. D. Casanave, General Superintendent of Motive Power, for the blue prints from which our illustration is made.

The poling car is essentially a short flat car, 20 ft. long over the end sills and 7 ft. 4 ins. wide over the side sills. There are two end sills, 10 × 10 ins., and six longitudinal sills, the side and intermediate sills being 5½ × 10 ins., and the two center sills (only 2 ins. apart) 5 × 10 ins. At the middle of the car are two rows of transverse blocking let into the sills. The body bolsters are flat steel plates, let into the sills and having their ends turned up against the outside faces of the side sills, being supported by heavy truss rods which pass through the turned up ends and are attached to loops on a strap resting on top of the center sills. Two heavy tie-rods pass longitudinally through the frame, close to the center sills, and each longitudinal sill is attached to the end sill by a bolt having a flattened strap end, this flat end being bolted through the sill. The design was prepared with a view to the racking and twisting strains to which the car is subjected in service. The car is mounted on two four-wheel trucks with 33-in. wheels, the truck wheelbase being 4 ft. 10 ins., and the total wheelbase 14 ft. 10 ins.

Over the sills is a decking of 1¾-in. planks, upon which is a framing of timbers 3¾ × 6 ins., carrying the floor of 1¾-in. planks. In the middle of this 6-in. space between the two floors are placed six 33-in. car wheels to weight the car down upon the track, while the end panels have horizontal diagonal bracing, as shown. A railing runs around the ends of the car, and a cabin or house is built in the middle and fitted with a stove and locker. This cabin is 5 ft. 3 ins. high, 5 ft. 9 ins. long, and only 3 ft. 9 ins. wide, leaving a gangway on each side for the men handling the pole. Two oak footboards, 1¾ × 4½ ins. and 1¾ × 8¼ ins., are placed along each side and end of the car, 17 and 28 ins. below the tops of the sills, and to each end sill is bolted a heavy coupler head, while at the front end are two large marker lamps. The car is fitted with air and hand brakes.

At the middle of each end sill is a heavy casting with two lugs having holes for the vertical standard which supports the pole lever. The pole is 6 ins. diameter and 10 ft. 1 in. long, its heel being pivoted to the vertical standard, between the two lugs. The pole is handled by a horizontal lever pivoted at the top of the standard, the inner end of the lever being counterweighted to balance the weight of the pole, and the outer end being connected to a shackle near the end of the pole by a tie-rod and turnbuckle. The pole can thus be swung round horizontally to engage with or clear the poling sockets attached to the corners of the freight car frames, and its end can be raised or lowered to adjust it to the varying heights of the cars. The platform is about 4 ft. 6½ ins. above the rails, so that the men are well placed for handling the pole. A curved arm supports the end of the pole when it is not in use. There is only one pole, with its operating standard and lever, but a socket casting is placed on each side of the car, and the pole can be transferred from one side to the other when necessary.



STANDARD POLING CAR; PENNSYLVANIA R. R.
F. D. Casanave, General Superintendent of Motive Power.

A NEW SYSTEM OF SEWER ASSESSMENTS IN BOSTON.

After trying a great variety of plans for raising the money required for sewerage purposes in Boston, and finding it next to impossible to secure sufficient funds to carry on the work under any of the methods tried, an entirely new system is just being put in operation. The system seems rather complicated, at first, but a very slight study of it will show this appearance to be largely due to the bringing together of several methods of raising money which have heretofore been carried on separately. The only innovation seems to be the raising of three-fourths of the cost of maintenance in the form of sewer rentals, and the other fourth by general taxation, instead of securing the whole amount by taxation.

The law which made this method possible was enacted by the Massachusetts legislature in 1897, through the efforts of Mr. Josiah Quincy, Mayor of Boston. It was drawn by Mr. Andrew Bailey, Corporation Counsel. It provides that there shall be annually determined, before the first day of July, just and equitable sewerage charges to be paid by estates in said city for the construction, maintenance and operation of the sewerage works of said city, taking into consideration the necessity of the works as caused by each estate, the amount of the use thereof, if any, by the estate, or its occupants, the benefit received therefrom by each estate, the amount of any assessments for a sewer paid by any owner of the estate, the length of time which has elapsed since such payment, and the use, if any, that has heretofore been made of the sewerage works by the occupants of the estate, and such other matters as shall be just and proper.

In working out the details of the new system, Mr. F. Herbert Snow, Assoc. M. Am. Soc. C. E., of Snow & Barbour, Sanitary Engineers, Tremont Building, Boston, acted in the capacity of consulting engineer to Mr. Benj. W. Wells, Superintendent of Streets, and his deputy, the Superintendent of the Sewer Division, Mr. C. R. Cutter. These gentlemen were assisted by Mr. J. Frank Williams, Assistant Engineer in Charge of the Record office, and by the Chief Engineer of the Sewer Department, Mr. E. S. Dorr. Mr. Cutter was selected to supervise the investigation of various methods for Mr. Wells and to report his findings.

Under the plan adopted, the total sum appropriated by the city council each year for the maintenance and operation of sewers is to be divided into two parts, of one-fourth and three-fourths, respectively. The one-fourth is to be raised by general taxation of all the land in the city and

the three-fourths on the basis of water charges on an amount of water used by each estate in the city.

The interest and sinking fund requirements for all sewerage bonds issued since June 21, 1897, are to be met in three ways, as follows: (1) By an assessment of $1.25 per ft. frontage on all land abutting on lateral sewers, using the word "lateral" to include all sewers with which house connections are made; (2) the cost of lateral sewers in excess of $1.25 per ft. frontage and of all district trunk sewers not used as laterals is met by general taxation of all the land in the district; (3) all the remaining charges for interest and sinking funds are to be raised by general taxation of all the land in the city. The bonds in question, it appears, run for 30 years.

The various sums chargeable, as described above, against any property are to be included in the regular tax bills and collected like other taxes.

We are indebted to Messrs. Wells and Snow for the information given. By referring to our issue of July 19, 1894, it will be seen that the new Boston plan is similar in principle to that recommended by Mr. Snow for Brockton, Mass., and adopted by that city. Besides Mr. Snow's exhaustive report for Brockton, which was abstracted in Engineering News of the date given above, those interested may consult with profit a symposium on the subject, giving the practice in six cities, published in the Journal of the Association of Engineering Societies for January, 1897.

TEST OF AN ELECTRIC STREET RAILWAY POWER PLANT AT BROCKTON, MASS.*

This test was made to determine the performance of some new machinery installed in the power house of the Brockton Street Railway Co., and included tests to determine the following data:

Boilers.—Evaporative performance, commercial horse power, rate of combustion and rate of evaporation.

Engine.—Speed regulation, power and efficiency.

Generator.—Efficiency and capacity. The engine is a 700-HP. cross-compound condensing engine built by the E. P. Allis Co., of Milwaukee, Wis., with cylinders 20½ and 38 × 48 ins. The flywheel weighs 60,000 lbs., the rated speed being 110 revolutions per minute. A 24 × 12-in. Reynolds independent steam air pump and a jet condenser are also used.

Two specially designed vertical water-tube boilers rated at 200 HP. each are used. These have 222 tubes 2½ ins. in diameter and 15 ft. long and furnish steam at about 115 lbs. gage pressure.

Boiler feed water was taken from the city water mains and pumped through the main feed-water heater, which utilized the engine exhaust steam, thence through an auxiliary heater, which received the exhaust steam from the pumps and condenser, to the boiler.

Coupled directly to the engine is a 10-pole 500-K-W. railway generator built by the General Electric Co., of Schenectady, N. Y.

Generator Tests.—The armature resistance was obtained by the "Fall of Potential" method; that is, the armature was put in series with a water resistance and the bus-bars of the old part of the station, which were connected with the other generators. The resistance was adjusted to allow 100 amperes to flow through the armature. The drop in pressure between the terminals of the armature, as shown by a low-reading voltmeter, divided by the current flowing (100 amperes), according to Ohm's law ($R = \frac{E}{C}$), gave an average value of 0.0189 ohms. In the same way the series or compound winding gave 0.0026 ohms and the shunt field 47.1 ohms; the resistance being measured in each instance while the machine was hot.

To obtain the "External Characteristic" or curve which shows the variation of the voltage of the machine under different loads, the engine speed was maintained constant and the load varied from 0 to 800 amperes by means of a water resistance. At zero amperes the voltage at the machine terminals was 500, at 800 amperes 510 volts and at 910 amperes, 550 volts.

The "Electromotive Force Curve," or the curve showing the different values of electromotive force between the brushes, was obtained by the third brush method, one terminal of a voltmeter being attached to one of the brushes and the other to a movable brush which was slipped around the commutator towards the other machine brush, readings being taken at frequent intervals from the voltmeter. In this case the plotted values gave almost a true sine curve.

The efficiency of the generator was obtained by running it as a motor, to do which it was necessary to disconnect the connecting rod at the crank-pin and the valve rods at the rocker arms, leaving the armature, flywheel, shaft, crank-disk, eccentric strap and rocker arms as the only moving parts. The shunt field was then excited from the station bus-bars. The armature was also connected to the bus-bars in series with the water resistance, already mentioned, which was gradually cut out until finally the armature was directly on the bus-bars and running at full speed. It was then found that the no load voltage at the machine terminals was 569; current through shunt field, 9.5 amperes; current through armature and series field, 47.5. This gave 569 × 47.5 = 27,027, say 27,100 watts, as the power required to turn the armature over at full speed without any external load. In other words, the amount of power necessary to overcome the internal losses of the machine, not, however, including C^2R losses, was 27,100 watts. The machine was rated at 500 K-W. and 550 volts at full load, or

$$\frac{500 \times 1{,}000}{550} = 910 \text{ amperes}$$

at full load.

$$\text{The efficiency} = \frac{W}{W + w + m}, \text{ in which}$$

W = useful output, or available output.
w = unavailable but used energy.
m = wasted energy, C^2R and other losses.

Using this to calculate the full load efficiency, we have

$$\frac{910 \times 550}{(910 \times 550) + [(550 \times 10) + 27{,}100] + [(910 + 10)^2 \times 0.0215]} = 90.8\%.$$

The stray losses (waste energy) and power required to magnetize the shunt field are practically the same for all loads, and the efficiencies for ½, ¼ and 1-10 load were calculated in the same way, using ½, ¼ and 1-10 the total current output.

The efficiencies found were lower than those guaranteed by the manufacturers, as shown in Table I.

TABLE I.

Load.	Per cent., efficiency. Found.	Guaranteed.	Corrected.
Full load	90.8	95.0	94.6
½	87.0	93.0	94.3
¼	78.7	91.5	91.8
1-10	60.4	...	...

This apparent discrepancy is explained by the fact that from 35 to 40% of the friction of a steam engine is due to the bearings and the air resistance to the flywheel's motion. The general value allowed for total engine friction is about 10% of the rated power, and this is practically constant for all loads. If the full load horse power be taken as 750, then 750 × 10% × 40% = 30 HP., or the amount of power absorbed by the bearings and air resistance to the flywheel.

Deducting 30 H.P., = 30 × 746 = 22,380 watts from the sum of the terms W + w + m in the efficiency calculations, the values given in the last column of Table I. will be obtained. These agree very closely with the guaranteed efficiencies.

The following table gives the results of the tests of boilers and engines.

The Boiler Test.

Date of trial	June, 1897
Duration of trial	10 hrs.
Number of boilers in use	2
Dimensions and Proportions:	
Grate surface of each boiler	33.18 sq. ft.
Grate surface, total	66.36 "
Water heating surface of each boiler	1,648 "
Water heating surface, total	3,296 "
Superheating surface of each boiler	502 "
Superheating surface, total	1,004 "
Ratio of water heating surface to grate surface	.50
Ratio of total heating surface to grate surface	.65
Average Pressures:	
Steam pressure in boiler, by gage, per sq. in.	112 lbs.
Atmospheric pressure per sq. in.	14 "
Absolute steam pressure in boiler per sq. in.	126 "
Force of draft in colm.of water beyond damper.	0 "
Average Temperatures:	
Of external air	85 deg.
Of fire-room	88 "
Of feed-water before entering 1st heater	68 "
Of feed-water before entering 2d heater	137.3 "
Of feed-water before entering boiler	197.1 "
Of escaping gases after leaving boiler	554 "
Of steam	384.4 "
Fuel:	
Moist coal consumed	10,140 lbs.
Moisture in coal	3.4%
Dry coal consumed	9,965 lbs.
Wood consumed	452 "
Coal equivalent of wood	189 "
Total dry coal consumed, incl. wood equivalent.	10,146 "
Total dry refuse	817 "
Total dry refuse	8%
Total combustible	9,329 lbs.
Dry coal consumed per hour	1,015 "
Combustible consumed per hour.	933 "
Quality of Steam:	
Number of degrees superheated	39
British Thermal Units:	
Heat units absorbed by boilers per lb. of steam generated	1021.4 B. T. U.
Factors of Evaporation:	
Factor of evaporation for boilers	1.06
Water:	
Total water pumped into boilers	98,119 lbs.
Water actually evaporated, corrected for quality of steam	100,007 "
Equivalent water from and at 212° F.	106,007 "
Equivalent water from and at 212° F. per hr.	10,601 "
Evaporation Performance:	
Water actually evaporated per lb. dry coal.	9.85 lbs.
Equivalent per lb.of dry coal from and at 212°F.	10.44 "
Water actually evaporated per lb. of combustible.	10.72 "
Equivalent per lb. of combustible from and at 212° F	11.36 "
Commercial Horse-power:	
On basis of 34½ lbs. of water from and at 212° F. per hour by boilers	307.3 H.P.
No. sq. ft. of total heating surface per horse-power.	14
No. sq. ft. of water heating surface per horse-power.	10.72
Rate of Combustion:	
Dry coal actually burned per sq. ft. of grate surface per hour	15.3 lbs.
Rate of Evaporation:	
Water evaporated per sq. ft. of total heating surface per hour from and at 212° F.	2.47 lbs.
Water evaporated per sq. ft. of water heating surface per hour from and at 212° F.	3.16 "

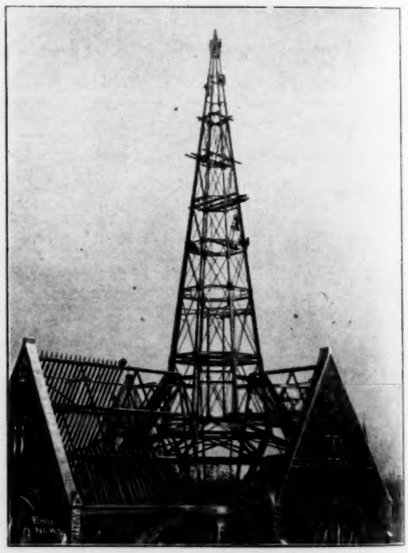


Fig. 1.—Steel Framework of Dome and Spire of St. Paul's Church, Chicago.

The Engine Test.

Duration of test	6 hrs.
Dimensions:	
Diameter of high pressure cylinder	20½ ins.
Diameter of low pressure cylinder	38 "
Stroke	48 "
Speed:	
Total revolutions of engine (6 hours)	38,536
Average revolutions per minute	107
Average pressures:	
Atmospheric pressure per sq. in.	14.5 lbs.
At throttle by gage per sq. in	112.0 "
At throttle absolute per sq. in	126.5 "
In receiver by gage per sq. in.	5.9 "
In receiver absolute per sq. in.	20.4 "
Vacuum in inches of mercury	24.0 "
Average Temperatures:	
In steam pipe at throttle	370.7° F.
In pond from which condensing water was drawn.	71.3° F.
In condenser discharge pipe	106.0° F.

*Abstract of an article in the August "Street Railway Journal," with additional information from Messrs. Stone & Webster, Boston, Mass., the engineers making the test.

Condenser:	
Diameter of air pipe	24 ins.
Stroke	12 "
Total revolutions of condenser (6 hours)	22,525
Average revolutions per minute	62.6

Steam Consumption:		
Total steam supplied to engine	64,927	lbs.
Steam per indicated horse-power hour	15.3	"
Steam per indicated horse-power hour when engine is running with 125 lbs. initial pressure and 25 ins. of vacuum (calculated from indicator cards)	14.4	"
Steam per electrical horse-power hour output.	17.2	"
Steam per kilowatt hour output	23.1	"
Coal Consumption:		
Water evaporated per lb. of dry coal	9.85	lbs.
Coal per indicated horse-power hour	1.57	"
Coal per electrical horse-power hour output	1.78	"
Coal per kilowatt hour output	2.4	"
Temperature of Parts at End of Test:		
Air of engine room	83.5°	F.
Main bearing low pressure side	120.0°	F.
Main bearing high pressure side	120.0°	F.
Armature	146.0°	F.
Commutator	146.0°	F.
Field coils	120.0°	F.

STEEL DOME AND SPIRE OF ST. PAUL'S CHURCH, CHICAGO, ILL.

The new St. Paul's Church, recently erected at the corner of Orchard St. and Kemper Place, Chicago, presents an interesting feature in the use of a structural steel skeleton framework for the dome and spire. The architects of the church were Messrs. Hill & Woltersdorf, and plans were invited for designs for a steel-framed dome and spire over the center of the church, one condition being that the members must be concealed by and not interfere with the domed ceiling provided for in the architect's design. This condition prevented the use of horizontal members between the masonry walls supporting the roof construction. The building is cruciform in plan, with the dome and spire over the center, and four gable roofs over the wings. Several designs for the steel framework were submitted, and the one selected was that prepared by Mr. Carl Binder, C. E., 903 Schiller Building, Chicago, by whom the work was carried on, and to whom we are indebted for plans and other information.

Fig. 1 is a view of the completed framework, showing the posts or columns of the spire resting upon one of the rings of the flat dome. The four roof trusses next to the dome are of steel, and to these trusses are attached the ribs of the dome, as shown in Fig. 2. The hip and valley beams are also of steel. Fig. 2 is a general plan and elevation, and clearly shows the character of the design. The base of the structure is formed by four A trusses which rest on the walls and have inclined bottom chords above the line of the ceiling. It will be seen that the horizontal member of these trusses forms also a part of the dome, and extends beyond the dome truss to the roof trusses. These members form an octagonal tension ring, to the corners of which are attached the ribs and bracing of the dome. Above this ring are an intermediate and an upper compression ring, the latter being 11 ft. above the tension ring, while from the former spring the eight ribs or columns of the spire, each of which is formed of channels connected by lacing bars. The height of the walls at the truss seats is 49 ft. 6 ins., and the top of the dome is 74 ft. 5 ins. above the ground. The belfry floor is 18 ft. 4 ins. higher, and above this the spire rises 127 ft. 3 ins., the total height from the ground to the top of the spire being 201 ft. 8 ins.

The eight ribs of the spire are connected by eight horizontal frames or bents, and unite at the top in a cap ring, above which rises the steel flagstaff. All the side panels, except those near the top, have diagonal bracing. Angle iron rafters attached to the main frames support the slate covering.

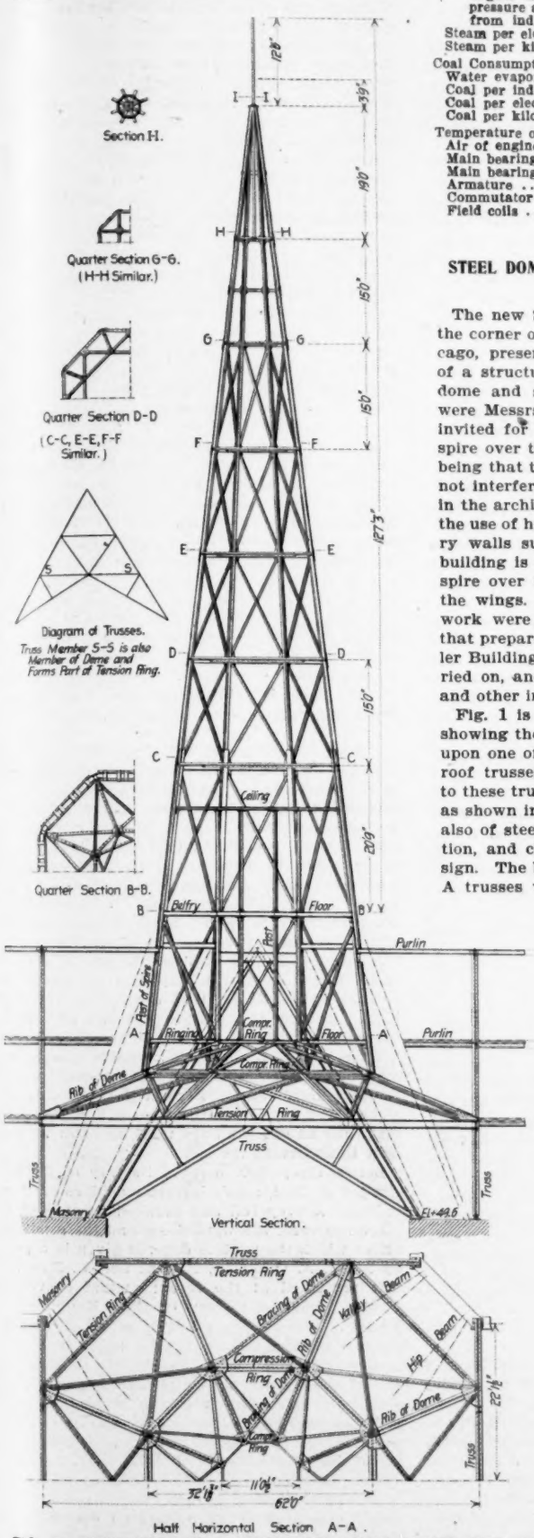


FIG. 2.—PLAN AND ELEVATION OF STEEL DOME AND SPIRE.
Carl Binder, C. E., Designer and Contractor.

Power and Efficiency:	
Average indicated horse-power	708.5
Total indicated horse-power hours	4,251.0
Average electrical horse-power output	627.8
Total electrical horse-power hours output	3,767.0
Efficiency of unit, per cent	88.6

The loads and wind pressure assumed for the design are as follows:

	Lbs. per sq. ft.
Roof, including covering and steel framing	28
Church ceiling	15
Ringing floor	100
Belfry floor	250
Wind pressure (horizontal) for main members	30
Wind pressure (horizontal) for anchorage and connections	45

The ironwork was manufactured by the Universal Construction Co., of Chicago, and had to be shipped in small pieces, the work of connecting and fitting being all done in place. For the trusses and the dome a square wooden trestle tower, about 60 ft. high, was used, but above this no falsework was employed. Very little adjustment was required in erection. The work occupied about 25 days, and cost about $8,400.

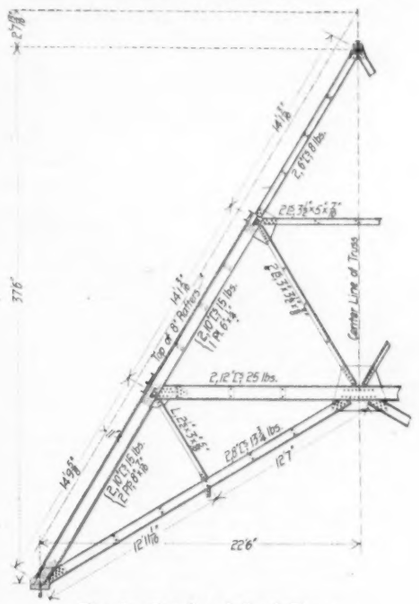


Fig. 3.—Details of Roof Truss.

THE RAILWAY SYSTEM OF PORTO RICO needs reorganization. Some years ago a line was projected making a circuit of the island along the coast line, and the provincial authorities finally made terms with a French company for its construction. This company promised to complete the belt system in six years, and the government gave the company the exclusive franchise for all railway construction for 99 years and guaranteed 8% on the cost of construction. Neither promise has been kept. Only three parts of the system are completed. The longest line is the 62 miles between San Juan and Camuy, on the north coast, with one train per day each way, besides two covering a part of the distance. Proceeding westward the finished work begins again at Aguadilla, and proceeds southward, 36 miles, to Hormigueros. At Yauco the line again begins and leads to Ponce, about 22 miles distant and on the south coast of the island. The company has also built a line, 14¼ miles long, from San Juan to Carolina. The three coast-line sections mentioned were built, equipped and put into operation within the time and in accordance with the terms of the franchise, as distinct parts of the general system. The provincial government accepted them under these terms, and recognized the obligation to pay the 8% interest; but the Carolina line has not been accepted by the government as complying with time and other conditions. When the first section was accepted the government began appropriating money annually to pay deficits and bring the interest-earning power up to 8%. Finally the people protested that the railway company was under obligations to build more railway and was not meeting its obligations, and payment on interest was stopped. Both of the French companies—one a construction company and the other holding the stock—have failed, and the charter has lapsed by its own terms, but has not been declared forfeited. No reports of operation are available, but freight rates are so high that transportation by ox-carts is said to be cheaper. The roadbed and equipment are in fairly good shape, all the latter being French in design and build. The gage of the road is 1.2 m., or nearly 4 ft., and the maximum speed is about 13 miles per hour. In addition to the lines named the same company has built a branch, of one meter gage, from Anasco, on the west coast, to San Sebastian, a distance of 21.7 miles. There is also a local tram-line, from San Juan to Rio Piedras, 6.8 miles long; and another tram from Catano to Bayamon, 6.2 miles long. This list includes all railways actually in operation on the island; and in this connection it is noted that most maps of Porto Rico show lines as in existence which are only projected.

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Engineering News takes pleasure in presenting to its readers with this issue the first complete and official map to be published of the district surrounding Santiago, Cuba, and of the positions of the United States and Spanish forces during the investment and capture of the city. We are also able to give the first published statement of the work done by the engineer division during the advance upon Santiago. This statement is of no small interest at this time, since several well-known magazine writers and newspaper correspondents in their accounts of the Santiago campaign have taken occasion to criticise the engineers of the army for failing to do their part in the work of the campaign.

In his paper on another page of this issue, Mr. E. J. Chibas, of the engineering staff of the 5th Army Corps, shows that, despite published statements to the contrary, a thorough reconnoissance was made of the country lying between the Spanish and American forces prior to the advance of July 1. In the building of piers, everything seems to have been done that the exposure of the shore and the limited material and time available for the work would permit. In the work of building roads and bridges, the engineer battalion appears to have labored heroically and well; and the only reason why the rivers had to be crossed by fords instead of bridges was that there was no means of transporting the sectional bridges and other material which were taken to Cuba in the hold of a transport, to the site where they were needed.

It will be borne in mind that the engineer troops which did service in the Santiago campaign were not the volunteer engineers, but the engineers of the regular army, who have had long drill in the especial work that falls to their lot, and the officers engaged in the work were almost entirely commissioned officers of the engineer corps. These men knew their business as well as the regular infantry and cavalry regiments knew theirs; and from Mr. Chibas' account it seems evident that, so far as the engineers at Santiago failed to do the engineering work that was needed, it was due to circumstances beyond their control.

The Nominating Commitee of the American Society of Civil Engineers, appointed at the Detroit Convention, has presented a full list of officers to be voted for in January next, and it heads this list with the name of Mr. Desmond FitzGerald, of Boston, as the candidate for President. We believe the committee has made a wise choice, both in the selection of an engineer who deserves the honor, and in awarding the office to a locality which has hardly had its proper share in the selection of the Presidents of this Society.

Mr. FitzGerald, during his many years of service in connection with the Boston water supply and other important engineering works, has won for himself an enviable professional reputation; and his name ranks high among the engineers whose original research and whose contributions to professional literature have brought hydraulic engineering in this country to its present position.

Besides the question of personal fitness, however, it is certainly important that in a truly national society like the American Society of Civil Engineers, the highest honor which it can bestow should be given with some regard to the representation of all sections of the country. The Society now has members in every state and territory of the Union, except Nevada, North Dakota and Oklahoma. Of course in many of these the members are very few and widely scattered. Under these conditions the equitable selection of a President by location is a somewhat delicate task, especially as precedent requires that the selection of candidates should be made from the engineers who have become prominent by a long and distinguished professional career. As a natural result of the last condition, candidates must be generally selected from the older sections of the country, where engineering works of magnitude are most plentiful, and where alone employment in the highest grade of professional work is to be found. In looking over the list of Past-Presidents of the Society and classifying them by location at time of election, we find, that New York State has furnished 11 Presidents out of a total of 28. This is almost half of all the Presidents, but it is accounted for by the original organization of the Society in this city and by the fact that for a long time the bulk of its membership came from this section of the country. As the interest in the Society spread, Presidents were selected from other states, and the general list to date, and excepting New York, reads about as follows: Pennsylvania, four Presidents; Missouri and Illinois, two each; Louisiana, Kentucky, Wisconsin, Ohio, New Jersey, Maryland, Massachusetts, Canada and the Corps of Engineers, U. S. A., one each.

It will be seen from the above that New England has furnished but a single President for the Society; yet a very large membership is located there. Massachusetts alone has 128 members of the Society, in all grades, and at least 70 of these belong to the City of Boston. The only President ever selected from Massachusetts, or, in fact, from the New England States as a whole, is the late James B. Francis, who was elected in 1880. The nomination of Mr. FitzGerald, therefore, is not only the bestowal of the highest professional honor on a worthy candidate; but it is an appropriate recognition of a geographical section, which, both in the number and quality of its members, is a most important component part of the American Society of Civil Engineers.

We desire to call attention to the new plan of sewerage assessments recently adopted at Boston, and described elsewhere in this issue. The plan is similar in principle to that in vogue at Brockton, Mass., reviewed at length in our issue of July 19, 1894. It is based on the fact that since a sewerage system confers both public and private benefits upon a community, its cost should be divided between the municipality as a whole and individuals; or, in other words, that a portion of the expenses should be raised by general taxation and the balance be met by individuals who are benefited. The private benefits are divided into two classes, the actual use of the sewers, and the increased value of property because of the mere fact that sewers are available. Under the Boston plan, of the total cost of maintaining the sewerage system, one-fourth will be raised by general taxation and three-fourths by rentals for the privilege of using the sewers. The cost of sewer extensions and improvements is to be met partly by assessments on frontage, and partly by taxation, thus recognizing both the private and the public benefit. To carry out this plan, all sewerage construction is divided into three classes, namely, lateral, district and main trunk sewers and works, and the cost is distributed among these classes, as explained elsewhere. The plan is one of the comparatively few attempts which have come to our attention, to distribute the cost of the construction and maintenance of sewerage systems in a way that shall be really equitable to all parties concerned. The use of water charges as a basis of determining rentals for the use of the sewers has the double advantage of apparent equity and of tending to prevent the waste of water. The new plan will probably add somewhat to the clerical work of the city, sewer and tax departments, but not so much as might be thought at first, since for years past the cost of most of the new sewers has been distributed between frontage assessments and general taxation, and the charge for maintenance has also been raised by general taxation. Once the various charges are computed, they are added to the regular tax bills and collected in bulk with the other taxes, thus doing away with the separate collection of special sewerage assessments. In cities where sewer extensions are made only on private initiative, and where sewer connections are not compulsory, the Boston plan might retard the development of sewerage systems, since the placing of a lateral sewer in front of one's property means an assessment, and a sewer connection means a yearly rental. But, as we pointed out in our review of the Brockton report, the system is so arranged as to place a part of the burden of sewers upon all real estate, and having this to bear already there is an inducement to take the next steps and secure the full benefit of the system.

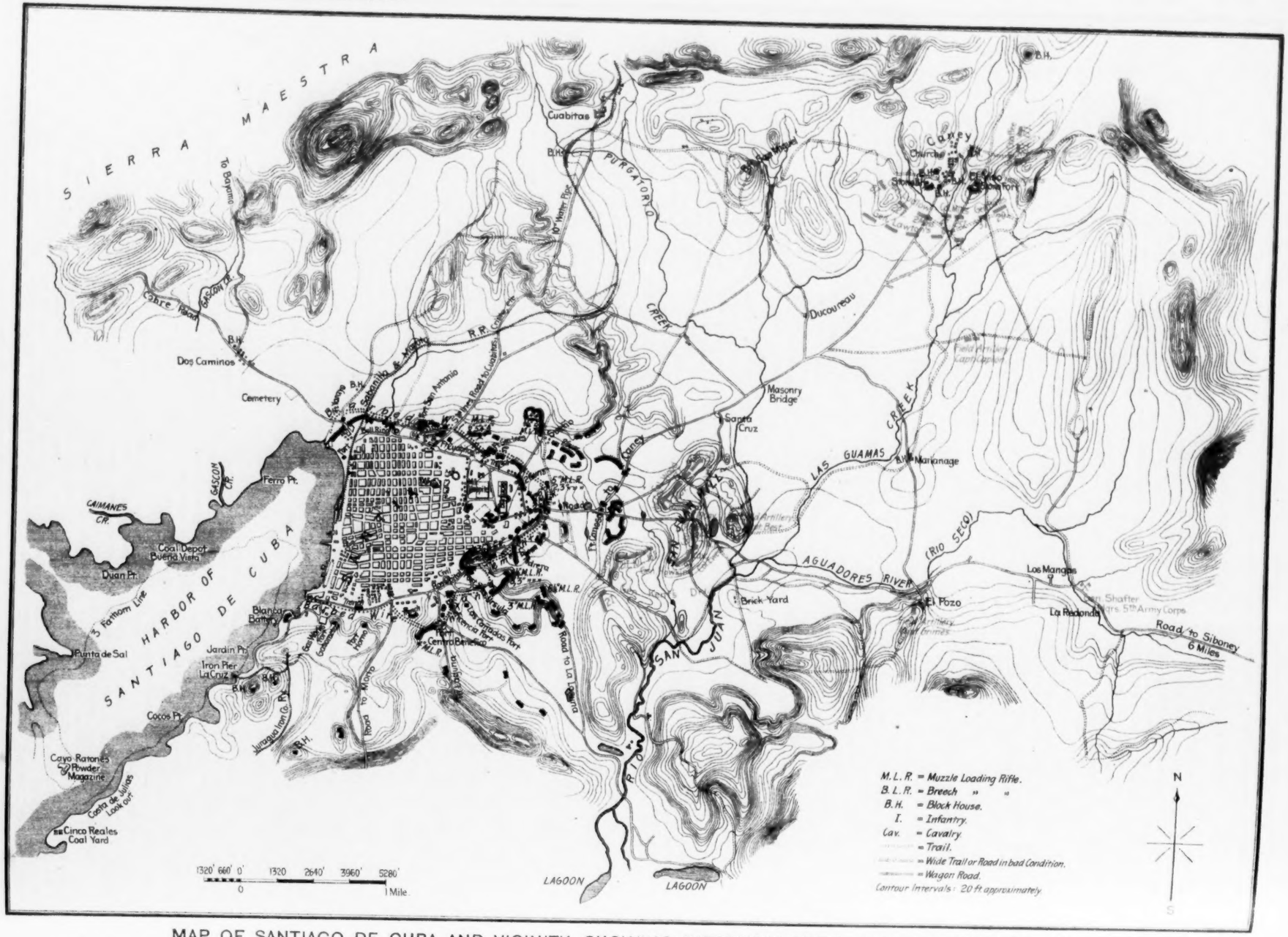
For over thirty years the Mississippi River has been the scene of extensive and costly experiments in removing the shifting sand-bars which impede navigation during the season of low water, but within recent years there have been adopted two general systems of improvement. The first of these is the establishment of permanent bank-protection works to rectify and improve the channel. The second is the use of hydraulic dredges of enormous capacity to cut channels through the bars which develop at every season of low water.

A peculiar feature of this dredging is that the entire benefit from it is reaped in the few weeks, or sometimes months, that the low-water season lasts. As soon as the depth of water in the river increases again, the shifting sands of its bottom are again set on their interminable travels, and long before the water comes again every vestige of the season's dredging work is wiped out. The same thing would be true even if dredges of ten times the size of the huge machines now at work were to undertake the task.

Beside the power to carve its way of the Mississippi in flood, man's largest machines are puny indeed. A very full and detailed account of the machines used, the work done, and the conditions under which the work is done, is given in a paper by Mr. J. A. Ockerson, M. Am. Soc. C. E., which was presented at the recent annual convention of the American Society of Civil Engineers, at Detroit. We give an abstract of Mr. Ockerson's paper in another column, but the paper is so comprehensive and so long that we are compelled to abbreviate it greatly. We would advise every engineer and contractor interested in dredging work and machinery to procure a copy of the complete paper, which is published in full in the June number of the "Proceedings" of the Society.

The paper forms a worthy addition to the list of remarkably good papers which have been recently presented to the Society on the bank-protection and levee building on the Lower Mississippi by Major Starling, Mr. Coppee and others.

The article describing a new method of measuring the power of a steam engine, announced in the bulletin at the top of our front cover page this week, is postponed to our next issue, by reason of delay in the preparation of the illustrations to accompany it.



MAP OF SANTIAGO DE CUBA AND VICINITY, SHOWING INTRENCHMENTS AND POSITIONS OF THE UNITED STATES AND SPANISH FORCES AFTER THE CAPTURE OF CANEY AND SAN JUAN HILL, EVENING OF JULY 1, 1898.

(Compiled from Surveys by Lieutenants Smith, Gordray, Bateon, White, Hoffman and Cheney, and E. J. Chibas, C. E., under direction of Lt.-Col. Geo. McC. Derby, Chief Engineer, Fifth Army Corps, U. S. A.)

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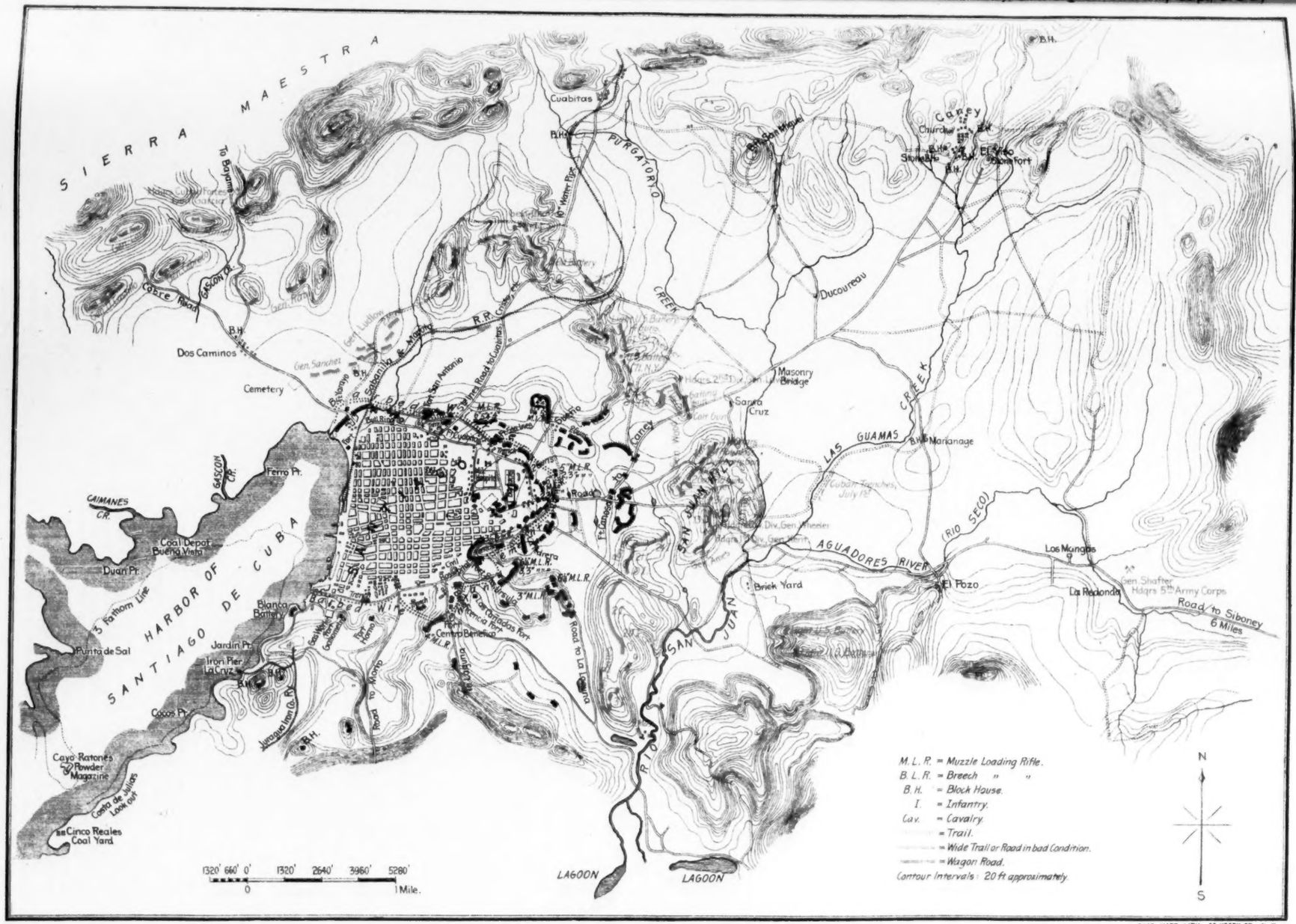


CHAS. HART, LITH., 38 VESEY ST., N. Y.

MAP OF SANTIAGO DE CUBA AND VICINITY, SHOWING
INTRENCHMENTS AND POSITIONS OF THE UNITED STATES AND SPANISH FORCES ON JULY 14, 1898.

(Compiled from Surveys by Lieutenants Smith, Cordray, Batson, White, Hoffman and Cheney, and E. J. Chibas, C. E., under direction of Lt.-Col. Geo. McC. Derby, Chief Engineer, Fifth Army Corps, U. S. A.)

THE COOLGARDIE PIPE LINE; A REMARKABLE ENGINEERING PROBLEM.

In our issues of Feb. 12 and 17 we described at some length the project for furnishing a water supply to the Coolgardie gold mining district in Western Australia, and criticised in some particulars the plans proposed for this work by an English Commission of Consulting Engineers. Since that time bids have been asked for the pipe to be used on this work, amounting to 246 miles of steel riveted pipe of 31 ins. diameter, and 3-16 to 5-16-in. thickness, and 82 miles of welded pipe of 26 to 29 ins. diameter and ¼-in. thickness. These bids were opened on Aug. 23, and no authentic statement of the award of the contract has yet been made; "The Iron Age," of Oct. 6, prints rumors that the contract has been awarded to two Australian firms, Mephan Ferguson, of Melbourne, and Hoskins Bros., of Sidney. Mr. Ferguson is the inventor of a novel longitudinal joint for steel pipes, which was illustrated and described in Engineering News of June 9 (p. 373), and which has been used on 8¾ miles of pipe for the Adelaide Water-Works. The above-mentioned rumor, however, still lacks confirmation, and our last direct advices were that to some extent, at least, the details of the conduit are still an open question.

We have also received, since we made our former comments on this scheme, the final report of the Board of Consulting Engineers (Messrs. Carruthers, Deacon and Unwin), upon the plans for this work, and very interesting reading it is.

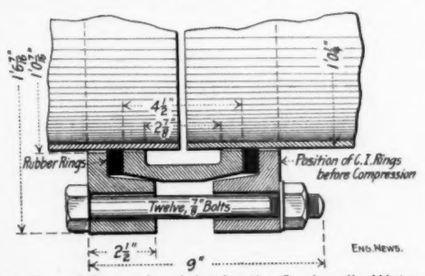
As our readers will recall, the project proposes the delivery of 5,000,000 gallons of water per day at a point in the interior of Australia, 328 miles from the reservoir in the mountains near the coast where it is impounded. To force the water through a pipe line for this long distance, not only must its friction be overcome, but it has to be actually raised a total vertical distance of 1,330 ft. Further, the district through which the pipe line passes is a desert whose soil is impregnated with salts, which are said to be so corrosive to iron that it is deemed safest not to bury the pipe in the ground at all. Another reason for leaving it exposed is that in a pipe line of such great length avoidance of leaks is essential. If an ordinary pipe line leaks a thousandth part of its flow in a mile, the loss may be a trifling matter; yet even so small a loss in a pipe line of this length would amount to nearly a third of its flow. In the arid desert through which this pipe line will pass, it is thought that the soil might absorb small leaks, so that they would not show at all on the surface of the ground if the pipe were buried. Facility of inspection, therefore, is another important reason for keeping the pipe above ground instead of burying it. Besides this, the ordinary reasons for burying water pipes—to get them out of the way, and to keep them from freezing in winter—do not obtain at all in the region over which this pipe line will pass; and as the cost of excavating and backfilling a trench 328 miles long will be saved by placing the pipe on the surface, the decision not to bury it seems, on the whole, a wise one.

The one great difficulty which is involved in keeping the pipe on the surface is the necessity of providing for expansion and contraction. In an ordinary line of pipe buried in the earth, the variation of temperature to which it is subjected is so small that the internal strains caused by the change of temperature do not reach serious proportions. To explain this more clearly! The modulus of elasticity of steel is about 30,000,000. That is to say, if a piece of steel of 1 sq. in. section be put under a tensile stress of 1 lb., it will be stretched $\frac{1}{30,000,000}$ of its length. The coefficient of heat expansion of steel per degree Fahrenheit is 0.0000065. That is, if a bar of steel be heated one degree Fahrenheit, it will be increased in length by $\frac{65}{10,000,000}$ of its original length. Dividing this coefficient by the one above given for the elasticity of steel, and we have a quotient of 195, as the stress per square inch that will be set up in a steel rod or plate by heating it or cooling it 1° F., and at the same time preventing it from changing its original length. Since the above coefficients are not exact, however, we may as well take the stress per square inch per Fahrenheit degree as 200 lbs., a quantity which is worth memorizing, as it is often convenient to use in calculations.

In an ordinary continuous steel conduit, buried in the earth in a temperate climate, the extremes of temperature of the water passing through it will probably not exceed 35°. If we suppose that the conduit is under no strain when at its mean temperature and is under compression during warm weather, and under tension during cold weather, the maximum internal stress will be:

$$\frac{35}{2} \times 200 = 3{,}500 \text{ lbs. per sq. in.}$$

Turning now to the Coolgardie conduit, to be laid unprotected on the surface of the ground, and with a distance between pumping stations as great as 75 to 80 miles, it is evident that the water confined from evaporation and exposed in a steel pipe to the fierce rays of the Australian sun, may reach a very high temperature in its passage from one pumping station to the next, which in the case of the longest conduits will require nearly three days. The English engineers estimate the range of temperature which will occur in the pipe line at 75°; and we should think this rather an under estimate. It will be seen at once that with such a range of temperature, internal strains would be set up in the pipe which might become so great as to cause movement and leakage at the circumferential joints. Expansion joints are, therefore, essential to the safety of the pipe; and the English engineers propose that such joints shall be placed at intervals of about 120 ft. for the whole length of the conduit, which would make a total of about 15,000 expansion joints in the length of the conduit.



Section of Expansion Joint for the Coolgardie Water Supply.

The engineering problem presented then (and one which we need hardly say is without precedent) is the design of an expansion joint for a pipe of 26 to 31 ins. diameter, which shall provide for a motion reaching ⅝-in., which shall sustain pressures reaching 200 lbs. per sq. in., which shall be and remain tight, with little or no attention, and which shall be as nearly as possible a permanent part of the pipe line. Our readers will be interested, we are sure, in learning what solution Messrs. Carruthers, Deacon and Unwin recommend for this problem. We, therefore, print this portion of their report in full:

Expansion Joints.—If the Coolgardie main is placed above ground, it is of the highest importance to have durable and efficient expansion joints. The amount of expansion to be provided for is large, about ⅝-in. per 100 ft. length, for a change of temperature of 75° F. So far as we know, no case has previously occurred in which the general expansion of a water main has required to be met by an extensive use of expansion joints. We have, therefore, been driven to consider and to recommend what is essentially a new expedient in such a case. It appears that, with such a range of movement, some form of stuffing-box joint must be adopted. After considering various forms, we have come to the conclusion that a joint on the principle of that used on the more recent Paris compressed air mains is well adapted to this purpose. (This joint is described in Reuleaux "Der Constructeur," 1869, as the joint of Normandy.) No form of expansion joint which has come under our notice, or which we have been able to devise, is simpler, cheaper, or likely to be more efficient than the Paris joint, although, so far as we can ascertain, it has not, up to the present time, been used for water mains, except for the joints of a 59-in. steel pipe, subject to a head of about 262 ft., recently constructed in connection with the water supply of Paris. The materials on which it depends have, however, been so used for a long time past, and we have no doubt whatever that a joint of this kind can be so designed as to be and remain perfectly watertight for such a time as would amply justify its adoption. Such a joint was constructed at our suggestion by Mr. Cleminger, the representative of Mr. Mephan Ferguson, patentee of the seamless pipe. We saw this joint tested on one of the seamless pipes several times up to a pressure of 500 lbs. per sq. in. It appeared so far to be quite satisfactory.

We next thought it necessary to carry out prolonged tests of the joint in such a manner that the movements due to expansion and contraction of the pipes would be imitated. We send with this report a drawing and description of the joint so experimented with. It is substantially the same as that used in Paris. The trials, which were carried out under the direction of Mr. Deacon, indicated that the details of the design could be improved, but notwithstanding some defects of the experimental apparatus, which on the whole were unfavorable to the endurance of the joint, the results of the trials are excellent, and, in our judgment, fully warrant the adoption of a joint on this principle.

The apparatus consisted of a 12-in. welded steel pipe, about 5 ft. long, divided transversely into three pieces, the two end pieces being fixed, and the middle piece—3 ft. long—being free to move axially to the extent of about ⅝-in. The joints shown and described on the drawing were placed round the open spaces between the three pieces. The pipe was charged with water maintained at a head of from 300 to 400 ft., and the central pipe was so connected with a steam engine that an approximately harmonic reciprocating motion in an axial direction, with periods of three to the minute, could be given to it.

We believe that if expansion joints are placed at every 120 ft. in the Coolgardie pipes, the maximum annual motion which ought to be allowed for will not exceed ⅝-in., and we think that this range is only likely to occur if the pipes are emptied during extremes of local temperature. We, therefore, made ⅝-in. the maximum range of motion at each joint, and we have imitated the smaller and more usual annual movements by ranges of about ⅜-in., and the diurnal movements in an exaggerated way, by ranges varying from ⅛ to 1-10-in.

Four different qualities of vulcanized India-rubber were experimented with, and the general result was to show that the dearer qualities were not the best for this purpose. With medium qualities, used in two rings, the full range of ⅝-in. was repeated 900 and 1,420 times, respectively, before any leakage occurred, while 13,000 and 16,000 double strokes, respectively, of ⅛-in. were given with another quality of rubber of the same price before any leakage occurred.

It is to be observed, moreover, that, on tightening up the bolts of the joints subjected to the ⅝-in. strokes, when the leakage amounted to about two drops per minute, they were further subjected to more than 13,000 double strokes of 5-16-in. each, during and after which no leakage occurred. We are satisfied that the diurnal contraction and expansion will not amount to anything like 5-16-in., and we therefore think that this may be regarded as a very severe test of diurnal work.

The above observations apply exclusively to the two rubber rings encircling the two ends respectively of the central moving pipe. But, owing to the construction of the apparatus, the two joints themselves move through smaller ranges, but more or less in proportion to the difference of recorded motions between the central pipe and the joint. In one of these, made with a ring of the lowest quality of rubber used, this motion of the joints in relation to the two fixed end pipes, varied from about ⅛-in. to about 5-16-in., during the first 2,500 strokes, and subsequently from about 1-10-in. to ⅛-in. throughout the remaining tests, covering 37,605 double strokes. The motion of the other ring, with the medium quality of rubber, varied from about ⅛-in. to 5-16-in., during the first 2,500 strokes, and subsequently from about 1-10 to 1-16-in. throughout the remaining tests, covering 37,605 double strokes. During the whole 40,105 strokes, both these outer rings remained perfectly watertight, and were still watertight after the experiments had ended.

It is believed that, unless leakage occurred, no sliding of the rubber took place, but that the whole of the displacement was satisfied by distortion of the rubber. It must not, of course, be expected that the rubber will endure for the number of years corresponding with the number of repetitions of double strokes of the longer ranges, each of which was completed in one-third of a minute. Other elements will probably conduce to the deterioration of the rubber, before the mechanical strains to which it will be subjected cause the joint to leak. But it is one advantage of this joint that the replacement of the packing is not a very serious matter. Other advantages are the lateral flexibility of the joints, which permits of considerable angular movement of any two adjoining pipes, and the facility with which any length of pipe may be rapidly removed and replaced.

On the whole, we regard the result of these experiments as most satisfactory, but the larger joint required for the Coolgardie main must be carefully and specially designed. In the case of the riveted pipes, a seating must be pro-

vided at the ends of the pipes to receive the expansion joints. This must be a steel ring with countersunk rivets.

The joint which was subjected to the tests above described is shown in the accompanying cut. It is a simple form of double stuffing-box joint. The details of the experiments upon it we do not reproduce, as they seem to us absolutely inconclusive. An expansion joint might work very well on a 12-in. pipe, and very poorly on a pipe of nearly three times the diameter. More important than this, however, is the fact that the tests ignored the element of time. The movement of the joint was effected by the deformation of the rubber packing rings, and not by their slipping on the surface of the pipe. Now, soft and elastic rubber has a very short life, especially in such a hot and dry climate as that of West Australia. The engineers, indeed, hint at this in one of the paragraphs above quoted; but they seem to think that the replacement of the packing rings will be no serious matter. Perhaps this may be true, if the packing can be renewed while the conduit is in service, and if the rings have a reasonably long life, say two or three years. It is by no means clear to us, however, that the packing rings could be renewed without emptying the conduit; and if the rings should require renewal every few months, it would very seriously interfere with the usefulness of the whole water supply plant.

At last accounts the question of the design to be finally adopted for these expansion joints was still open. The specifications on which bids were received Aug. 23, did not require the contractor to furnish the expansion joints, although a clause provided for the receipt of designs in which the longitudinal seams of pipes were made by other means than welding or riveting, accompanied by designs for expansion joints suitable for such pipes. Whether any such designs were received, we are not yet informed.

In searching for previous instances of the use of expansion joints on long lines of pipe of large size, the only example we have been able to find is the system of underground mains of the New York Steam Co. In this system, expansion joints made of thin corrugated copper plates are used; and have proved eminently successful. The joints were fully described by the late Chas. E. Emery, their inventor, in Trans. Am. Soc. C. E., Vol. XXIV., p. 188. The largest of these pipes, however, are about half the diameter of the Coolgardie conduit, and the application of joints of this type to pipes of such large size might involve some difficulties. The advantage of an all-metal expansion joint, with no parts depending on a sliding contact, or on the elasticity of perishable materials, is evident enough, and would be worth considerable added first cost to secure.

Turning now to some other features in connection with this project, we note that the specifications require all plates and pipes to be dipped in a bath of dilute sulphuric acid and scrubbed if necessary to remove the mill scale, followed by a bath of lime water. The plates must then, before exposure to the weather, be dipped in a bath of Trinidad asphalt and creosote of a composition satisfactory to the engineer. The pipes must be heated to about 300° F., before dipping in the bath.

The Commission of English engineers, in their report, remarked that the asphalt coating on the exterior of the pipes, if unprotected: "Will soon dry and become brittle by exposure to sunshine, and lose those properties which cause it to adhere to steel." To prevent this they recommended that, after laying, the pipe should be given a coat of lime whitewash with enough size to make it adhere firmly.

Steel for the pipes must be open-hearth acid steel, with ultimate strength between 25 and 29 tons, elongation in 10 ins. of 20% and reduction of area of 45%. A drifting test is also required as follows: A ⅝-in. hole punched within 1¼-in. of the edge of the plate must drift cold to 1⅝-in. without signs of fracture. Hot and cold bending tests may also be made to the satisfaction of the engineer.

The welded pipes are to be made in lengths of 9 ft. 2 ins., and these are to be riveted up at Midland Junction, West Australia, into 27½-ft. lengths. The joining up of these lengths into the 110-ft. lengths, which will be joined by stuffing-boxes, is to be done by the Colonial government. The unit lengths for the riveted pipe is 7 ft., and these will be joined up into 28-ft. and 112-ft. lengths. Longitudinal seams in riveted pipe will have two rows of rivets. The joinings of the rings will be on the telescopic plan, every alternate ring being of smaller diameter than the rings on either side by twice the thickness of the plate. All rivet holes may be punched except those in the circumferential seam by which the 28-ft. lengths are joined together.

To prevent creeping of the pipe, an anchorage will be provided at the middle of every 112-ft. length. Here two of the 7-ft. rings are joined by a butt joint and cover ring, and three pieces of angle iron are riveted on for attachment to the anchorage.

In our review of the project in our issue of Feb. 17, we suggested that the use of wood stave pipe for the Coolgardie pipe line would solve the many difficulties from contraction and expansion and corrosion by the soil. We are informed, however, that the pressures on most of the line will be so great as to make this class of pipe inadmissible. Its use is under consideration, however, for a large mileage of smaller pipes which will be necessary in distributing the water from the main reservoir at Coolgardie to the various towns and mining camps in the district. A question in connection with its use on which more information is desired is to what extent water is lost from existing wood stave pipes by small leaks and by evaporation from the surface of the pipe. The latter, it is thought, might be a source of considerable loss in a climate so dry as that of West Australia, if the pipe line were exposed to the sun for long distances. If any of our readers can furnish us information upon this point we shall be pleased to receive it.

LETTERS TO THE EDITOR.

Duty Record of the Indianapolis Pumping Engine.

Sir: I notice in your issue of September 29th an abstract of a report made by me to the Indianapolis Water Company upon a test of the 20,000,000-gallon Snow pumping engine recently installed at Indianapolis, in connection with which you refer to the performance of the Leavitt pumping engine at the Chestnut Hill Station, Boston, as published in the edition of Peabody's Thermodynamics, just issued. You note that while the duty, on a heat unit basis, of the Indianapolis engine is higher than that of the Leavitt engine, the steam consumption per horse-power per hour of the Leavitt engine is lower. I would add, as a fact which is of interest in this connection, that it appears from the data to which you refer that the Leavitt engine worked under a steam pressure of 175.7 lbs., which is 20.1 lbs. higher than the pressure available for the Snow engine.

Respectfully, W. F. M. Goss.

Purdue University, Lafayette, Ind., Oct. 8, 1898.

NOTES AWHEEL IN BOSTON AND VICINITY.

(Editorial Correspondence.)

For some years past Boston and vicinity has been the scene of a large amount of interesting engineering work, much of which is still in progress. A large part of this work is being carried out to meet the municipal wants of what may be called the metropolitan district. Most of it has been described in Engineering News at some stage of its progress. The following notes relate chiefly to work in the metropolitan district. They were secured on a bicycle trip made the latter part of September. The writer found a wheel a most excellent means of getting about the metropolitan district, the distance between points of interest being short, the grades generally easy and the roads for the major part of the 250 miles traversed most admirable. The days were long ones, but they need not have been so long, nor the total distance so great had not the writer wished to make his headquarters at picturesque and historic old Concord.

In recording what he saw and heard, no attempt will be made to follow the order of the trip. Instead, facts bearing on the different pieces or systems of work will be brought together.

The Metropolitan Water System.

Enough work on this system had been accomplished early this year to permit the introduction of water from the Nashua River, supplementing the supply from the Sudbury River and Lake Cochituate and cutting off the Mystic supply, which was objectionable in quality. The water from the Nashua River is diverted by a temporary dam, just above the site for the permanent one, into the Wachuset aqueduct, which changes to an open channel and empties into what was formerly known as Basin No. 5 of the Boston water-works, but is now the Sudbury Reservoir of the Metropolitan System. From here on, the waters of the Nashua are mingled with those of Boston's smaller sources of supply, passing through the old aqueduct. From the Chestnut Hill reservoir the mingled waters are pumped for the high service of the district. Some of it goes to Spot Pond, the former supply of Malden, Melrose and Medford, and part of this will again be repumped to a high service reservoir described later on, both Spot Pond and the new reservoir being in the beautiful Middlesex Fells Reservation of the Metropolitan Park System.

At the Chestnut Hill pumping station a 30,000,000-gallon Allis high duty pumping engine is now being erected, and three 35,000,000-gallon low duty Allis pumps, working under a head of some 60 ft., are to be placed in a new pumping station. The high duty pump is a fine piece of workmanship. Its pump cylinders will support the rest of the machine.

It is hoped that the contract for the new dam at Clinton will be let next spring. About 1,000 wash drill and 30 diamond drill borings were made at the site of the dam in 1895 and 1896. Connected with this reservoir there will be two immense dikes, the North one being about 9,500 ft. long and the South one, about 4,000 ft. long. The latter will have a core wall, but the former will not. The contract for the eastern part of the North Dike was let on Aug. 22 to Joseph Genarro, of Boston, and work was already well under way when the writer visited Clinton. The maximum fill on this section will be about 85 ft. Preliminary wash drill borings were taken on every square of 100 x 100 ft., and on the center line of the dike the same kind of borings were taken at intervals of 50 ft. Some of these were 265 ft. deep and their average depth was about 110 ft. The location of the North dike will be about 100 ft. nearer Clinton than that recommended in the special report of the Massachusetts State Board of Health. A cemetery is included in the site, from which the remains must be removed. The contract for the western portion of this dike and for the whole of the South dike have not yet been let. The dikes will have outer slopes of 4 to 1, and will be composed principally of the soil which is to be stripped, as a sanitary precaution, from the site of the reservoir. The central part of the North dike will be constructed of selected material, and there will be a secondary wall of selected material some distance down the slope, outside of the first one. These precautions are being taken to prevent the possibility of sliding which might occur if water should get into the soil composing the dike and change it to a somewhat pasty mass.

The new reservoir at Clinton will have a storage capacity of over 60,000,000 gallons, or about double that to be formed by the New Croton Dam. It will have a length of 8½ miles and a shore line of 35½ miles. New highways will probably be constructed around the reservoir, about one-third of this having already been done.

One of the most interesting features of the new reservoir is the blotting out of a large part of two towns and the destruction of the water power of the Lancaster Gingham Mills, employing 2,500 hands, when working full force. The mills have been paid about $500,000 for their water power, and are spending some $600,000 for improvements, most of which will be for the installation of a steam and electric plant. The mills will hereafter be operated by electricity, in 100 to 150-HP. units, thus doing away with long lines of shafting. Mr. Chas. H. Richardson is agent for the Lancaster Gingham Mills.

Altogether millions of dollars will be spent for the sanitary protection of the waters of the new reservoir at Clinton. The bulk of this will be for stripping the site of organic matter. In addition, a sewage disposal system for the city of Clinton will be built. Contracts have been let for this work and construction started. It includes about a mile of intercepting sewers, having a maximum diame-

ter of 30 ins., a 600,000-gallon receiving reservoir, a pumping plant and 23½ acres of filtering area divided into 25 beds. The reservoir will have a bottom and roof of groined arches, built of Portland cement concrete, 4 parts screened gravel, 2½ parts sand and 1 of cement. The centering of all arches is to be placed before any are built, the desirability of which practice seems to have been impressed upon Boston engineers by the recent failure of the reservoir roof at Wellesley, Mass. The bottom of the reservoir is designed to sustain the upward pressure due to a 12-ft. head of water, the reservoir being close by the river. For about a half month each year the ground water level may be 5 ft. higher. To provide against this, that is, to keep the head at 12 ft., instead of 17 ft., underdrains are to be laid beneath the bottom and a relief pipe carried up through it, with its top at such a level as to draw off 5 ft. of ground water. The reservoir is to be 100 ft. in diameter, with elliptical groins at the top, and circular at the bottom, the bottom to be filled in as desired to facilitate draining and cleaning.

The high service reservoir in the Middlesex Fells, mentioned above, will have a storage capacity of 38,000,000 to 40,000,000 gallons. It will be formed partly by excavation, much of which is in rock, and partly by five dams. The dams have concrete core walls, plastered with cement. The bottom of the reservoir will be covered with 4 ins. of Rosendale cement concrete, and the inner slopes of the dams, to 4 ft. below low water, with 4 ins. of Portland cement concrete. The inner slopes of the dams will be 2 to 1, as far as the lining extends, and 4 to 1 above that, graveiled. In rock excavation the slopes will be given no treatment, unless on trial it proves necessary to prevent leakage, or unexpected fissures develop as the work progresses. There will be a division wall formed partly by natural rock, the balance being of concrete. The water surface, when the reservoir is full, will be at elevation 271, Boston datum, and its bottom will be 17 ft. lower. Two pockets of muck are being removed, one going down 12 ft. below the bottom. The reservoir, as stated above, will be filled from Spot Pond, not far distant, by pumps yet to be placed in a station not yet built. Spot Pond has a high water surface of 154 ft., or 20 ft. above the Chestnut Hill Reservoir, from which water is now pumped to supplement the yield of the drainage area of the pond. A 36-in. force main will lead from the Spot Pond pumping station to and through the new reservoir, so the service may be direct, if desired.

Mr. F. P. Stearns, M. Am. Soc. C. E., is Chief Engineer of the Metropolitan Water System, with Messrs. Jos. P. Davis and Alphonse Fteley as Consulting Engineers. The heads of the several departments are as follows: Distribution, Dexter Brackett; Sudbury, Desmond FitzGerald; Dam and Aqueduct, Thos. F. Richardson; Reservoir, Hiram A. Miller. Mr. Reuben Shirreffs is Principal Office Assistant. All of these gentlemen, it is hardly necessary to say, are members of the American Society of Civil Engineers.*

The New State Road in Concord, Lincoln and Lexington.

The state road work of the comparatively few states that have taken it up with vigor and intelligence has now been in progress long enough to show most admirable results, both in state roads completed and in the stimulus given to improved road building by local authorities. Naturally, with limited appropriations available and large mileages demanding attention, the work must be done piecemeal. But after a few years stretches of fair length are developed in some sections. One of the longest of these in Massachusetts, and a fine example of road work, too, extends for some seven miles in the towns of Concord, Lincoln and Lexington, on the route from Concord to Boston. The work was begun in 1895 and has been continued each year since. A missing length has just been completed, and a start is just being made on a section continuing on well into the center of Concord.

Under the statutes authorizing this work, the towns in which it is done have the privilege of taking the contract for it. At first each of the three towns took the contract, Concord subletting it, but this year none of the work is being done directly by the towns. The towns were thus compelled to buy stone crushers, rollers and other road building plant, one of them after having voted down such a proposition yearly for many springs in the town meeting. This town has since been building some improved road on its own account, thus fulfilling one of the great objects of the state work and of letting the towns take the contracts for it.

On the stretch of road being finished there were in use a Buffalo Pitts Co. steam roller, of about ten tons net weight, and a Studebaker sprinkler, with very wide tires and wheels gaged to overlap, thus acting as rollers. The improvement consists of 15 ft. of macadam, with 5-ft. shoulders, making a total width of 25 ft. The macadam is 6 ins. deep at the center and 5 at the sides, in three layers. The first layer is of 2½-in. stone 4 ins. deep; the second of 1¼-in. stone 2 ins. deep; and the last is of dust from the crushers. The gravel shoulder is 6 ins. deep. The gravel is paid for by the yard, spread, blue gravel hauled some distance costing 60 cts. per cu. yd., on this year's contract. Most of the stone is of trap rock, from ledges along the road, but some is field stone, hauled by farmers. The crushed stone cost $1.45 per ton, in place. There is but little competition. For culverts, the inside masonry is of rubble, and the outside is laid in Portland cement. Where there is only 2 ft. of dirt fill above the culverts iron pipe is used for the channel; where more than this, sewer pipe, the diameter generally being 12 ins. Sometimes a stone channel is used. The roads are drained with tile pipe, where necessary, and always when they abut upon banks or hillsides.

The crown of the roads is ¾-in. per ft. of width for macadam and 1 in. for the gravel. This brings to mind one of the greatest faults of the ordinary road; it is allowed to sag so that that water runs in it on grades and stands in it on level stretches, to the destruction of the road in either case.

Fences are placed where necessary for safety. They consist of 6-in. chestnut posts, 8 ft. c. to c., with the upper edge of the top rail 3½ ft. above the ground. This rail is 4 ins. sq., set with corner up, being notched half its width into the post and having joints formed by halving the ends onto each other. Half way between the rail and the ground is a 2 × 6-in. plank, generally let into the post from 1 to 2 ins. The rail and plank are of spruce, planed, and given one coat of white paint. The rails and plank are in 16-ft. lengths, and break joints. This fence costs about 15 cts. per lin. ft.

At intervals along the state roads notices, printed on cloth, are posted, warning the public that

> any person who injures or defaces trees, guard rails or other structures, or disturbs or removes road material or other property of the Commonwealth on any State road will be prosecuted.

The placing of placards, signs or advertising devices within the limits of state roads is also prohibited. Quotations are also made from the Acts of 1893, Chap. 476, Sec. 14; Acts of 1894, Chap. 497, as amended by Acts of 1897, Chap. 355, Sec. 1, all bearing upon the making of openings in and repairs to the state roads. These roads are placed under the police jurisdiction of the local governing bodies.

Most of the information given above was obtained from Mr. F. P. Cutter, of Lexington, Mass., Resident Engineer on the road work described. Mr. Mills is Chief Engineer of the Massachusetts Highway Commission.

The Metropolitan Park System.

Only a part of one day could be devoted to the park system. The start was made from Concord, Mass., over the seven miles of state road already described, then through Arlington to the Mystic Parkway, extending along the Mystic Lakes. At Winchester a turn was made into the Middlesex Fells, crossing here over a causeway dividing the Winchester reservoir and passing along Spot Pond, up and down hills and out on the Malden Boulevard. The Mystic Parkway is an example of engineering and landscape work carried to a high state of perfection, but without over-elaborateness or too much ornamentation. In the Fells, science and art have attempted little or nothing except to make the beauties of nature accessible to man. Men were at work raking stones from the roads and clearing up tangled underbrush. The roads were mostly in good condition, but with rather heavy grades, which last could not be avoided, perhaps, without making too deep gashes in the hills.

One rather startling thing that met the eye in these woods was a piece of bagging tied around nearly every tree, a few feet from the ground. The vast amount of work involved in this is a good example of what the carelessness of one man may cost a whole state or nation. Years ago a naturalist brought home some Gypsy moths to this country as specimens, and allowed them to escape. They have so multiplied and proved so destructive that the state of Massachusetts is now spending some hundreds of thousands of dollars annually in the endeavor to exterminate them.

From Malden the course taken led on through several towns to the Revere Beach Reservation, a strip of ocean front which has been provided with an immense bath-house and a grand boulevard a mile or more in length, connecting with a fine piece of state road. During the past season 140,400 bathers patronized this bath-house, the greatest number in a single day being 5,508 on a Sunday. The total number would have been greater had it not been for a fire on Sept. 6, caused by overheating in the drying room. This was confined to the upper floor of the bath-house, but damaged the drying room and offices to the extent of some $30,000. The establishment was in operation again in two days, the work, where necessary, being done by hand. The beach is accessible from Boston in a very few minutes' time, and the fare each way is only 5 cts., by either the electric cars or the Boston, Lynn & Revere Beach Ry. Thus Boston has provided what is, perhaps, an unparalleled seaside resort, available for the humblest.

The curbstones and gutters along the boulevard are of concrete, made in sections, in place. The curb is about 7 ins. wide at the top, 9 at the bottom, and 18 ins. deep. The gutter is some 2 to 2½ ft. wide. Tar paper is placed between each joint. The curbs are of ordinary concrete, faced with ¼-in. of neat Portland cement. All the stonework around the shelters is of the same material, which was all built by the Murdoch Parlor Grate Co.

Mr. Chas. H. Howes is the Resident Engineer at the Beach, and Mr. Wm. T. Pierce is the Chief Engineer of the Metropolitan Park Commission.

The Massachusetts-New York Boundary Line.

A remarkable piece of instrument work in the way of long sights was described in our issue of Dec. 23, 1897, in connection with a re-establishment of the boundary line between the states of Massachusetts and New York. Subsequent surveys have verified the accuracy of this line, which was 38 miles between points, and it has been officially adopted by the State of New York, through its state engineer, Mr. Campbell W. Adams. The engineers of 1787 stated in their report that they had run the line as closely as possible with the instruments available, and the recent work shows that they did remarkably well, considering their facilities.

Boundary posts are now being set along the line at all highway and railway intersections, mile posts and important summits. Of these posts 44 are of 12 × 12-in. × 9-ft. New Hampshire granite, at highways; 38 are of 12 × 12-in. × 5-ft. Connecticut granite, at mile points or summits; and 29 are iron posts of 97 lbs. weight, 5 ft. long, about 4 ins. in diameter, with small oval heads. On one side of each head are the letters MASS, and on the other N. Y. The posts are set in concrete and their exposed portion is painted white, with the letters in black. Mr. Henry B. Wood, M. Am. Soc. C. E., is Engineer of the Massachusetts Topographical Commission, and we are indebted to him for the information given.

Improvements to the Water-Works of Winchester, Mass.

A high service system is now being added to these works, with Mr. F. L' Fuller, M. Am. Soc. C. E., 12 Pearl St., Boston, as engineer. A 20-HP. oil engine will drive a 500,000-gallon triplex Gould pump, lifting water to a stand-pipe 40 × 40 ft. With a full stand-pipe the lift will be about 125 ft.

*Previous articles on the Metropolitan Water System may be found in Engineering News for March 7 and April 4, 1895, and Feb. 25 and March 4, 1897.

The engine is of English design, known as the Hornsby-Akroyd, made by the De La Vergne Refrigerating Co., of New York.

DREDGES AND DREDGING ON THE MISSISSIPPI RIVER.*

By J. A. Ockerson, M. Am. Soc. C. E.

About 1870 the use of temporary expedients for improving the channel of the Mississippi River gave place to a system of permanent improvements, consisting of the closing of chutes, the contraction of wide places by means of jetties or dikes, and the revetment of banks. The inauguration of this policy, to the exclusion of temporary expedients, was evidently a mistake, due probably to the fact that the length of time required before tangible results could be realized by the so-called permanent method was very much underestimated.

In the meantime, competition of railway lines along the banks of the river, and difficulties of navigation, threatened to annihilate the river traffic. Immediate temporary relief must be found, or the river as a great commercial highway must be abandoned. In response to the appeal of the steamboat men, temporary channel improvements were again taken up, and were made obligatory by Congress, for the lower river, in the River and Harbor Bill of June 3, 1896.

In 1883 a plant was provided for dredging in the Mississippi River above the mouth of the Illinois River. This plant consisted of an Osgood dipper-dredge and six dump-scows, the whole plant costing $29,348. It was used with good results.

In 1887, a contract was entered into for a hydraulic dredge and decked flat-boats to support 500 ft. of discharge pipe, to be used in the district above named. Experience had shown that a dipper dredge could do good work under favorable conditions, but for opening temporary channels through bars it was found to be too slow in its operations and hence too expensive. A dredge provided with a centrifugal pump for pumping sand and water from the channel and delivering the same through pipes far enough away to clear the channel was manifestly an improvement. This hydraulic dredge was equipped with a Van Wie pump with a 14-in. intake and a 12-in. discharge. The pump was run at 330 revolutions per minute and the material was lifted about 9 ft. above the surface of the water and discharged from 300 to 800 ft. from the pump. The intake nozzle was provided with a jet supplied by a Worthington pump, to aid in stirring up the material so that the suction could take hold of it.

While this dredge was evidently a move in the right direction and was very useful in the upper river, its capacity was entirely inadequate to meet the requirements of the lower river. Here the dredging required at a single bar often exceeds 100,000 cu. yds., and the time permissible to remove this large amount of material is very short. To successfully accomplish this result machines were required of far greater capacity than any heretofore used or known.

In November, 1891, the representatives of steamboat transportation lines below St. Louis appeared before the Mississippi River Commission and urged immediate relief for low-water navigation. They stated that if such relief depended on the completion of the permanent improvement work, by the time it came, there would be no traffic. In response to this appeal, the Commission appointed a committee of two to study the subject of the construction and operation of such appliances for dredging as can be applied to the deepening of the Mississippi River over the bars in extreme low water; . . . and to prepare and report a project for the construction of a dredging boat of as large capacity as can be handled in the channel of the Mississippi River at low water with safety and convenience.

Col. Chas. R. Suter and the late Henry Flad, both members of this Society, were designated to serve on this committee. After a thorough investigation of the matter, the committee concluded that among the various devices for temporary relief, dredging was the only means which held out a reasonable promise of success. The problem involved so many new features in the way of the enlargement and combination of devices heretofore used, that the construction of an experimental dredge was recommended. Drawings and specifications for an experimental dredge were prepared under the direction of this dredging committee, and contracts for the construction of the various parts were let at the close of 1892.

Dredge "Alpha."—This experimental dredge was equipped with an Edwards centrifugal pump having a curved drag-suction at one end, and an Allis-Reynolds screw pump having a straight suction with jet agitators at the other end, the object being to make practical tests of the efficiency of the different devices. The pumps, engines and boilers were designed by their respective manufacturers. The Edwards pump runner was 6 ft. 4 ins. in diameter, and was operated by a compound non-condensing, vertical engine with cylinders 15 and 27 ins. in diameter, and 20 ins. stroke. The suction and discharge were each 30 ins. diameter. The Allis-Reynolds pump was operated by a similar engine, with cylinders 8 and 16 ins. diameter and 12 ins. stroke. The suction and discharge pipes were each 30 ins. in diameter. The jet pump was of the Allis-Reynolds pattern, with 15-in. suction and discharge. This pump operated six jets 2½ ins. in diameter under a head of about 20 ft. By this means the material was loosened and divided up so as to enter the suction of the sand pump thoroughly mixed with water.

The machinery was mounted on a wooden hull 130 ft. long, 36 ft. wide and 8 ft. deep. The dredge in working order drew about 4 ft. of water.

The material pumped was discharged through a floating pipe-line made up of sections of pipe 33 ft. long, connected by means of strong rubber joints and iron coupling bars. An air chamber on each side of the discharge pipe served to float it when loaded with 10% or less of sand. In order to operate the dredge, two hydraulic piles are set about 25 ft. apart, near the upper end of the bar to be excavated. A wire rope about 1,000 ft. long is attached to each of these and to the hauling drums on the dredge. If the wind does not deflect the dredge from its proper place, it is allowed to swing freely in the current with the discharge pipes trailing below it. If necessary, side piles are set, and by means of lines attached to them, the dredge can be hauled into such position as may be desired. In dredging, the boat is pulled ahead up-stream at rates varying with the depth of the material taken out, the average movement being about 60 to 75 ft. per hour. After one cut is finished, the dredge is dropped down again to the lower end of the bar, the head piles are moved over about the width of the cut and another cut is made near by and parallel to the first. This process is repeated until a channel of the required width and depth has been secured.

There is perhaps no single feature which facilitates this method of dredging as much as the hydraulic mooring piles.* The ease with which they can be set and withdrawn, and their great holding power, make them really indispensable where dredging is done in strong currents. They are sunk 15 or 20 ft. deep in the sand, and the head lines are attached to a shackle down at the surface of the sand, and consequently there is little danger of bending.

In the fall of 1894 the first attempt to aid navigation was made near Cape Girardeau, Mo., where there was a bar about 1,600 ft. long with from 3 to 4 ft. of water. Work began on Oct. 19, and by Oct. 26 a channel 6 ft. deep had been made and this channel remained good throughout the season.

With a view to get the benefit of the best dredging experience available, a circular was sent out in August, 1894, to engineers, contractors and builders of dredges, inviting "informal plans and suggestions as to the methods and machinery best adapted to the work." The capacity of the required dredge was to be 1,600 cu. yds. of sand per hour. Several replies were received, and three firms were requested to prepare detailed drawings and specifications of the plant they proposed to furnish. These were submitted in December, 1894, and a contract was let to the American Hydraulic Dredging Co., of Chicago, for the construction of the dredge "Beta," at a cost of $172,775. The dredge was completed and ready for testing in January, 1896.

Dredge "Beta."*—This dredge has two independent dredging machines complete from suction to end of discharge pipes. The sand pumps are of the centrifugal pattern, with runners 7 ft. diameter and with 8 arms in each runner. The suction for each pump is 33¾ ins. diameter, and is split near the pump so that the water enters the casing from both sides. The discharge for each pump is from a single 30-in. pipe leaving the pump chamber from the top. The suction for each pump divides near the forward end of the hull into three sections, each 19½ ins. in diameter. A cast-iron elbow is riveted to the hull at the bow for each of the three branches, which are provided with elbows of hammered copper ⅝-in. thick, and these work in the iron elbows and form a radial telescopic joint. The axis of rotation is the center of a 7-in. shaft supported on brackets at the bow of the boat. These three suctions are framed together and can be raised or lowered, as one piece, through a depth of 20 ft.

Each of these suctions is provided with a vertical revolving cutter, 5 ft. in diameter, and 5 ft. long, with 12 nickel-steel blades on each cutter. These serve to loosen up the material so that it will readily enter the suction. There are six of these revolving cutters for the two pumps. They are spaced 6 ft. apart, c. to c., and are driven, through a system of spur gearing, by a cross-compound, non-condensing engine with cylinders 14½ and 29 ins. diameter and 18-in. stroke. The engines make about eight revolutions to one revolution of the cutters.

To support a portion of the weight of the cutter machinery, a pontoon is provided for each set of suctions. This pontoon is made of steel plates, and is built around the various pipes and frames. Each pontoon has a displacement of 1,000 cu. ft.

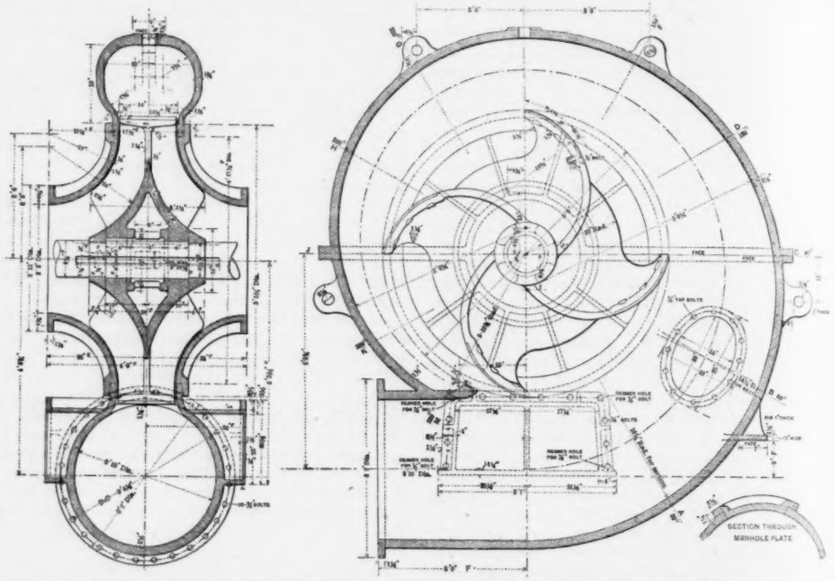


FIG. 1.—CENTRIFUGAL PUMP OF THE HYDRAULIC DREDGE "GAMMA"; MISSISSIPPI RIVER.

Each pump is operated by a direct-connected, triple-expansion, vertical, inverted, four-cylinder, tandem engine provided with jet condensers. The cylinders are 20½, 33, 38 and 38 ins. in diameter, and 24-in. stroke, with the cranks set at right angles. These engines are run at a speed of about 130 revolutions per minute, each being of about 1,250 I. HP., with boiler pressure of 175 lbs. Each engine is provided with a Worthington duplex air pump and jet condenser, with cylinders 14 and 19 ins. and 15-in. stroke. They are also arranged to exhaust without condensing. The steam is supplied by four Heine boilers, and mechanical filters are provided to free the boiler feed from water sediment.

The winding engines are placed near the bow of the boat. There are six drums, operated by a double cylinder, link-motion, reversing engine with cylinders 12¼ ins. diameter and 15-in. stroke. Four of the drums are 24 ins. in diameter and 40 ins. long. Two of these drums are used for side warping, and are geared 25 to 1. The other two are used for pulling the dredge ahead, and are geared 30 to 1; 1,200 ft. of ⅞-in. wire rope is used for this purpose. The two end drums, 30 ins. diameter and 28 ins. long, are used for raising and lowering the suctions.

At the stern of the boat is a steam capstan and a spud hoist. There are also two vertical anchor-spuds and one push-spud at the stern of the boat. The anchor-spuds are of oak, 24 ins. square and 40 ft. long. These were intended mainly as pivots on which to swing the boat, so that a wide cut could be made by moving the suction on the arc of a circle, but this method is not well adapted to streams with a strong current.

The machinery is mounted on a steel hull 172 ft. long and 40 ft. wide. It is 7 ft. 2 ins. deep in the waist, and for 36 ft. from the forward end and 16 ft. from the after end it is

*We are obliged to condense largely this long and interesting paper, which was presented at the annual convention of the American Society of Engineers at Detroit, in July. The paper is published in full in the June number of the Society's "Proceedings."

*A similar mooring pile, used on a later dredge, was illustrated in our issue of July 22, 1897.

*Illustrated and described in Engineering News of April 23, 1896.

10 ft. 10 ins. deep. These deep portions are decked over, as are also the guards, for the entire length.

The requirements of the contract fixed the limit of draft at 4½ ft., and the width at 40 ft. When the dredge was completed, the draft was found to be about 6½ ft. The total displacement when running, with suction and discharge pipes, boilers, filters, heaters, etc., full of water, and a supply of coal on board, is about 1,175 tons.

The discharge consists of two independent pipe lines, each 1,000 ft. long. A deflecting baffle plate is provided for the end of each line. Eight of the sections of each line are 100 ft. long, and four sections are 50 ft. long. When the pipes are empty, the pontoons draw about 14 ins. of water.

A number of defects were developed in the use of this dredge, many of which were remedied. At first the cutters all worked in the same direction, and the result was that the dredge was pulled sidewise out of the cut. This was remedied by changing one set of cutters to work in the opposite direction. The breaks in the gearing of the cutter machinery were frequent, although the spur gears were made of nickel-steel, and the pinions of phosphor bronze. The 6-drum hoist also gave considerable trouble. The cutters were found to be very much longer than necessary, and their operation drew heavily on the boiler capacity. The unexpected draft developed difficulties in coaling, and in manœuvring the dredge over the shoal bars.

The preliminary tests of the dredging machinery began in January, 1896, and continued until March. Of the 400 working hours embraced in this period, 255 hours were used in repairs and changes, and 74 hours in actual pumping. The capacity tests were begun on March 10 and continued for about a month. The tests show an average capacity of 4,920 cu. yds. per hour, and, therefore, according to the terms of the contract, a bonus of $86,387 was earned by the contractor.

During the low-water seasons of 1896 and 1897, the enormous capacity of the "Beta" was fully demonstrated. Before the dredge is again put into service for the low-water season of 1898, numerous changes will be made. The hull will be widened to 56 ft. and lengthened, so as to reduce the draft to 4½ ft. About $41,000 has been retained from the contract price to do this work, as the specifications required that the draft should not exceed 4½ ft. The cutter engines, cutters and other parts belonging to the present suction will be replaced by a jet suction and pumps. This is done because it has been found in actual practice that mechanical agitators are unnecessary in the sands of the Mississippi River. The wear and tear of the cutter machinery is a very large item of expense, to say nothing of the power required. The jet agitators are quite efficient, are much more economical in point of repairs and power required, and are more simple in manipulation. The push-spud and one anchor-spud will be discarded. The other anchor-spud will be moved to the bow of the boat, and the spud-hoist will be discarded. The forward battery of boilers will be turned end for end in order to properly distribute the weights under the new arrangements, and to improve the facilities for coaling. Much of this work would probably be deferred were it not that the boat must be put into dry dock to make the hull repairs, and this opportunity is seized for making the changes outlined.

Dredge "Gamma."—The Act of Congress of June 3, 1896, was the first to formally recognize and require the use of dredge boats and other devices as an adjunct to the permanent improvement of the lower Mississippi River. The act requires that as much of the money appropriated as may be necessary

shall be expended in the construction of suitable dredge boats and other devices and appliances, and in the maintenance and operation of the same, with a view to ultimately obtaining and maintaining a navigable channel from Cairo down, not less than 250 ft. in width and 9 ft. in depth, at all periods of the year, except when navigation is closed by ice.

This formal recognition of the necessity of temporary relief for low-water navigation resulted in the construction of four more dredges.

The contract for the "Gamma" was let in July, 1896, to the Bucyrus Steam Shovel & Dredge Co., of South Milwaukee, Wis. The capacity required was 800 cu. yds. of ordinary river sand per hour, delivered through 1,000 ft. of pipe with a single centrifugal pump.. The price paid was $85,530, and the time fixed for completion was nine months. This dredge was used in actual work throughout the low-water season of 1897, and was found to be very satisfactory, both in capacity and economy. The hull is of steel, and is 178 ft. long over all, 38 ft. wide and 8 ft. deep. There is a well at the bow, 32½ ft. long, in which the suction is placed.

The main dredging pump is a centrifugal pump, with a 24-in. suction inlet on each side and a 34-in. discharge at the bottom. The runner is 5 ft. 9 ins. in diameter, and has four blades. It revolves at a speed of about 150 revolutions per minute. The pump is driven by a cross-compound, condensing engine with an independent condenser. The high and low pressure engines are horizontal, and are connected to two disk cranks set at right angles and keyed to opposite ends of the pump shaft. The cylinders are 18 and 32½ ins. in diameter, and 22-in. stroke. The high-pressure cylinder has an adjustable cut-off, with a hand adjustment to regulate the point of cut-off. Expansion relief-valves are provided for the low-pressure cylinder. These engines develop about 500 HP., with a boiler pressure of 140 lbs. The jet pump is of the centrifugal type, with 18-in. suction and discharge. This pump supplies the water to stir up the sand at the suction head. The runner has four arms, with steel tips, running as close as practicable to the casing, to obtain the greatest available pressure. This pump is shown in Fig. 1.

The main hauling winches are located on opposite sides of the boat near the bow. They are driven independently and are provided with fast and slow feed controlled by clutches. The drums are 42 × 42 ins., giving space for 1,200 ft. of ¾-in. wire rope. Each drum is driven by a pair of 7 × 7-in. double cylinder engines, with cam reverse, and the power is transmitted through a combination of worm and spur gearing. The movement is controlled by means of a brakewheel and strap. The speed ratio is 81 to 1 for fast, and 493 to 1 for slow speeds. The hoisting engine for raising the suction pipe has a drum 24 × 24 ins.

The anchor-spud is hoisted by means of an upright, single-acting, steam cylinder, 18 ins. in diameter and 6-ft. stroke. The piston is attached to a cam clamp at its upper end, which grips and holds the spud against the slides. Steam enters at the bottom of the cylinder through a three-way valve, raising the piston and spud to the height of its movement. When the valve is turned to the exhaust port the piston and clamp descend, the spud being supported by a rack and pinion. The pawl locking the pinion is hinged between its center of movement and point, and the tripping is effected by making the pawl buckle on itself so that the point turns under. This releases its hold and allows the spud to drop.

Steam for this plant is furnished by six boilers 48 ins. in diameter and 28 ft. long, with five 11-in. flues in each. They are designed to carry a pressure of 140 lbs. In front of the fire doors are coal bunkers having a capacity of 40 tons.

The two intake pipes at the pump casing run forward to the suction head. They are hinged to the boat at the bow by two flanges connected by a pivot pin on the lower side and provided with a circular stuffing-box, making a radial joint that will allow the suction to be lowered to a depth of 15 ft. Outside of the joint the pipe and suction head are framed together and rigidly connected so as to form essentially one piece. At the suction head the pipes are 11 ft. apart, c. to c. The suction head for each pipe is 8 ft. long and they are 3 ft. apart, forming one suction head 19 ft. long over all. The suction head proper has two inlets, one for the upper and one for the lower intake, and between the two is a triangular pressure chamber running the whole length of the head. This connects directly with the jet pump. This chamber has nine 2¼-in. nozzles through which the water from the jet pump is forced with sufficient pressure to loosen the sand in front of the suction. The discharge pipe is 34 ins. in diameter. The floating discharge pipe is 1,000 ft. long, divided into 20 sections, each 50 ft. long. They are made of ¼-in. tank steel, and the pipes are floated by means of 40 cylindrical pontoons, each 23 ft. 9 ins. long and 30 ins. diameter.

This dredge was tested near St. Louis, Mo., in August, 1897, and, after the completion of the tests, was used in actual dredging between Cairo and Memphis until early in December of the same year. The general efficiency test, called for by the contract, required that the dredge should be operated 60 working days of 12 hours each in water from 5 to 15 ft. deep, and with sand of such different degrees of coarseness as will be found on the low-water bars. After this had been done and the machinery found satisfactory, then 20 capacity tests were required to be made with the suction at different depths. This last requirement was considered filled when the total amount pumped per hour divided by 20 was equal to or exceeded the required capacity of 800 cu. yds. per hour.

The total weight is 1,019,623 lbs., and the working draft of the dredge is about 46 ins.

Construction was begun in June, 1896, and the dredge was practically completed in March, 1897.

Dredge "Delta."—This dredge was constructed under contract with the New York Dredging Co., which sublet the construction of different parts to various manufacturers and builders of machinery. The contract price for this dredge was $124,940. It differs from the "Gamma" chiefly in having a mechanical agitator instead of jets, in its hoisting and hauling winches, and in the form of pump. Its capacity is also somewhat greater. Its construction was begun in June, 1896, and it was practically completed by the end of June, 1897. After the tests were finished, this dredge was used in removing sand bars below Cairo throughout the low-water season of 1897.

The hull is of steel, 175 ft. long, 38 ft. wide, and 8¼ ft. deep.

The dredging pump is different from those on the dredges heretofore described, in the shape of the casing and the runner, Fig. 2. The runner has five blades 22 ins. wide, and is 7 ft. in diameter. The edges run close to the casing, but the runner is not concentric with the casing, hence the outer ends of the arms are nearer one side of the casing than the other, the widest space being at the bottom, and the space being nearly cut off by a projection in the casing at the upper side of the discharge opening. The axis of the pump is parallel to the axis of the boat and lies over the center line of the same. The shaft has one long bearing through the aft side of the casing, and is provided with water bushing under pressure to keep the sand out of the bearing. The sand pump is driven by a vertical, inverted, two-crank, compound-condensing engine, with cylinders 22 and 48 ins. diameter and 24-in. stroke. It is fitted with a piston and slide valve and has an adjustable cut-off for the piston valve. This engine was designed to develop 800-HP. at 140 revolutions per minute, with a boiler pressure of 160 lbs. and a vacuum of 25 ins.

The engine which drives the cutters is horizontal, two-cylinder and non-reversible, attached to a sliding steel frame, which moves back and forth in guides as the cutter is raised or lowered. This is necessary because the shaft which drives the sprocket chain is not in the axis of motion, on which the suction and cutter revolve. The whole engine, with its frame, follows the motion of the shaft, so that the gear and pinion are always engaged. To admit of this motion, the steam pipes are provided with slip joints. The cylinders of this engine are 12½ ins. in diameter and 15-in. stroke, with the locomotive type of slide valve.

There are two winding drums located forward of the sand pump, one on the starboard and the other on the port side of the hull. These drums are provided with clutches and brakes, and are driven by two independent double-cylinder, horizontal engines with cylinders 10 × 12 ins.

The ladder hoist for raising and lowering the suction, and the spud hoist for raising the spud, each have drums 24 × 24 ins. The cables from these drums lead to the roof and thence out through sheaves to the ladder and spud. These drums are operated by the same engines that operat the winding drums.

Steam is supplied by four Heine safety water tube boilers rated at 250 HP. each.

The intake of the sand pump is from one pipe 34 ins. in diameter, entering in the axis of the pump at the forward side of the casing. This single pipe runs 25 ft. to the forward bulkhead and there branches into two pipes, each 24½ ins. in diameter, which separate and pass through the bow of the boat below the water-line, 9 ft. apart. These two pipes turn to the right and left square along the outside of the bow and then turn forward again and each branch separates into two pipes 17½ ins. in diameter, which connect with the suction head. The whole is framed together so that the four pipes, suction head and cutters are raised and lowered together as one piece. Instead of a radial slip joint for the suction pipes, as used on the dredges already described, there is a vertical flanged joint in the horizontal part of each pipe next to the bow, and the revolving pins that sustain the weight of the aft end of the suction are placed in the prolonged axes of these pipes.

The cutter for loosening up the material is placed at the outer end of the suction head. It has 22 cast-steel wheel cutters, each having four blades mounted on a steel shaft 6⅞ ins. square. This shaft is driven by the cutter engine by means of two steel sprocket chains, at a rate of about eight revolutions per minute.

The floating discharge pipe is 1,000 ft. long, with the usual rubber couplings at intervals of 50 ft. There are pontoon floats on each side of this pipe, U-shaped in section, with the flat side closed, and they sustain the pipes in yokes which are firmly attached to the floats. There is a baffle plate at the end of the pipe line. The dredge is provided with sixteen hydraulic piles, six of which are 10 ins. in diameter and 38 feet long, and ten are 6 ins. in diameter and 25 ft. long.

The total approximate weight is 1,375,608 lbs., and the weight of the floating pipe line is 221,477 lbs. This dredge was launched on Feb. 20, 1897, and the tests were completed Aug. 11, 1897.

Dredges "Epsilon" and "Zeta."—The construction of these dredges was begun early in January, 1897. They were built under contract with the Springfield Boiler & Mfg. Co., of Springfield, Ill. The work done by this company at its own shops was confined chiefly to the hulls, floating pipe lines, boilers and other plate work. The pumps, engines, etc., were sublet to other manufacturers.

The stipulated capacity of these dredges is 1,000 cu. yds. of ordinary river sand per hour, dredged from a maximum depth of 15 ft., and delivered through 1,000 ft. of floating pipe.

The dredges are alike throughout, except that the "Epsilon" has water jet agitators, and the "Zeta" has mechanical agitators. The contract price of the "Epsilon" is $102,000, and of the "Zeta," $106,000.

The hulls are of steel, 157 ft. long, 40 ft. wide and 7½ ft. deep. There is a well at the bow 35 ft. long, 18 ft. wide at the hull, and 22½ ft. wide at the forward end. There are two open spaces in the hull, one for the engine and pumps, and one for the boilers and coal bunkers. All other parts are decked over. It is divided into 11 water-tight compartments by two longitudinal bulkheads and five cross bulkheads.

The main sand pump, Fig. 3, is located on the axis of the hull, in the forward part of the engine pit. It is similar in form to that on the "Gamma," having a divided suction, consisting of two 24-in. pipes, admitting the water on both sides of the casing, and the shaft of the runner extends through the casing with a bearing at each side. The main bearings of the pump runner are protected from sand by means of a ring of water under pressure supplied by the fire pump. The discharge is from the bottom of the casing and is 32 ins. in diameter. The pump runner is 5 ft. 9 ins. in diameter and has seven blades 11⅝ ins. wide at the outer ends. It is run at a speed of about 160 revolutions per minute. Pressure gages are provided to show the suction and delivery heads.

The main engines which operate the pump are connected to the ends of the shaft passing through the pump runner by means of flange couplings. There is a tandem-compound engine at each end of the shaft, each having cylinders 16 and 26 ins. in diameter and 18-in. stroke. The cranks are set at right angles with one another. These engines are balanced in a horizontal direction, and automatic governors are provided to regulate the speed. They are designed to develop 650 HP. at about 180 revolutions per minute, with a boiler pressure of 150 lbs.

long, and 42 ins. in diameter, operated by a double engine with 8×8 ins. cylinders. The spud hoist is located just behind the anchor spud, and is also operated by an 8× 8-in. double engine. It is used for raising or lowering the anchor spud. The drum is 21 ins. long and 42 ins. in diameter. The operator stands on an elevated platform behind the winches and controls their movements by means of vertical levers.

On the "Zeta" the jet pump is omitted and a mechanical agitator for stirring up the material is used. This agitator consists of a vertical scraper or harrow attached to the front end of the suction head, which is given an up and down motion by means of a bell crank. It is divided into two parts, which are suspended in front of the suctions. A connecting rod or pitman extends from each agitator back to the rear end of the well, where it connects with a second oscillating crank operated by an engine with cylinders 10×14 ins. These engines are connected through gearing to a common shaft extending entirely across the boat. In order to lessen the danger of breakage from snags or other solid obstructions, a shearing pin is provided at the angle of the forward crank, which is so arranged as to shear off before sufficient strain can come on the agitator to break it. Mechanically considered, its movements are quite satisfactory. In the tests, however, it was demonstrated that the capacity of the pump with this agitator was not much over half the capacity of the pump with jet agitators. It will, therefore, be taken out, and jets will be put in. This device is the invention of Edward Flad, M. Am. Soc. C. E.

Steam for the various machines is derived from six boilers, 48 ins. in diameter and 28 ft. long, with three

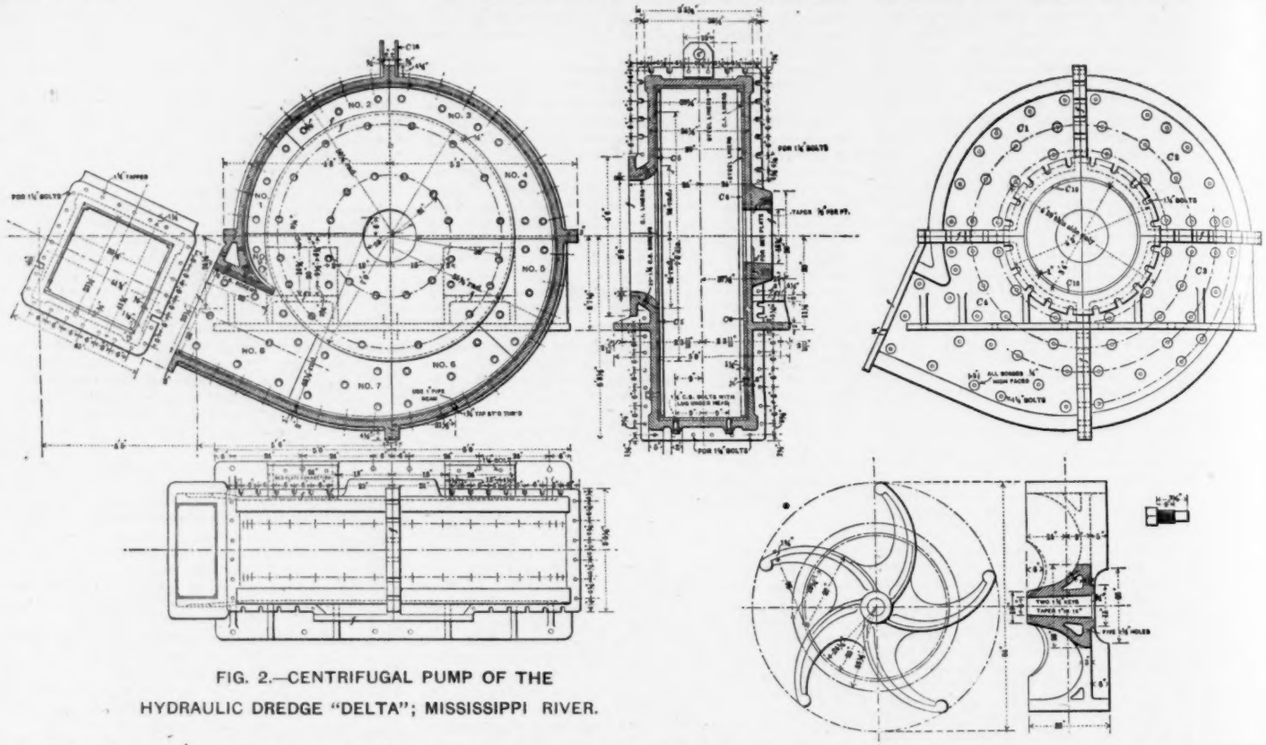


FIG. 2.—CENTRIFUGAL PUMP OF THE HYDRAULIC DREDGE "DELTA"; MISSISSIPPI RIVER.

The "Epsilon" has a 15-in. centrifugal jet pump operated by a vertical cross-compound engine with cylinders 12 and 22 ins. in diameter and 12-in. stroke. The engine is on the same base as the pump, and is directly connected by a flanged coupling.

The winding engines and the hoisting and hauling drums are located near the bow of the boat. The drums are 42 × 42 ins., and hold about 1,200 ft. of ¾-in. wire rope in two laps. Each drum is operated by an 8 × 8-in. double cylinder engine provided with a link reverse and suitable clutches and brakes giving fast or slow motion, as may be required. The suction hoist drum is 14 ins.

11-in. and two 13-in. flues. They are designed for a working pressure of 140 lbs.

The two suction pipes run forward from the pump casing, separating gradually until 12 ft. apart at the bow. At this point a tight radial joint is provided, which connects the pipes in the hull with the pipes from the suction head, and admits of the vertical motion necessary for dredging at different depths. The suction can be lowered to a maximum depth of 15 ft. Outside the hull the two suctions are framed together rigidly and are handled as a single piece. The raising and lowering is accomplished by means of sheaves and tackle attached to a derrick

TABLE NO. 1.—DIMENSIONS AND EQUIPMENT OF DREDGES WORKING ON THE MISSISSIPPI RIVER, BELOW CAIRO.

	"Alpha."	"Beta."	"Gamma."	"Delta."	"Epsilon."	"Zeta."
Name of dredge						
When built	1893.	1895.	1897.	1897.	1897-98.	1897-98.
Cost	$87,000	$217,000	$86,000	$125,000	$102,000	$106,000
Capacity in cu. yds. of sand per hour	600	2,000	800	1,000	1,000	1,000
Hull: Kind	Wood.	Steel.	Steel.	Steel.	Steel.	Steel.
Hull: Size	140′ × 36′ × 8′	172′ × 40′ × 7′ 2″	138′ × 38′ × 8′	175′ × 38′ × 8′ 4″	157′ × 40′ × 7′ 9″	157′ × 40′ × 7′ 9″
Hull: Working draft	4′ 10″	6′ 6″	4′ 3″	4′ 3″	4′	4′
Main engines: Number	1	2	1	1	2 coupled.	2 coupled.
Main engines: Kind	C'mpound non-condensing.	4-cyl. triple, exp., 2-crank condnsg.	Hor. cross-compnd. condensing.	Vertical compound condensing.	Hor. tandem coup. non-condensing.	Hor. tandem coup. non-condensing.
Main engines: Size	15″—27″ × 20″	20½″—33″—38″ —38″ × 24″	18″—22½″ × 22″	24″—48″ × 24″	16″—26″ × 18″	16″—26″ × 18″
Main engines: Horse-power	300	2,000	500	800	650	650
Main engines: Revolutions per minute	140	135	150	150	180	180
Main engines: Kind of condenser	None.	Jet.	Jet.	Jet.	None.	None.
Main dredging pumps: Centrifugal	1	2	1	1	1	1
Main dredging pumps: Diameter of runner	6′	7′	5′ 9″	7′ × 28″ wide.	5′ 9″	5′ 9″
Main dredging pumps: Kind of suction	Side.	Divided.	Divided.	Side.	Divided.	Divided.
Main dredging pumps: Diameter of suction	30″	Six 10½″	Two 24″	Four 17½″	Two 24″	Two 24″
Main dredging pumps: Discharge pipes—Number	1	2	1	1	1	1
Main dredging pumps: Discharge pipes—Size	30″	33″	34″	34″	32″	32″
Main dredging pumps: Suction head in ft. of water	7	18	9	18	12	12
Main dredging pumps: Delivery head in ft. of water	20	29	37	45	28	28
Main dredging pumps: Velocity—ft. per second	10	14	10	15	13	13
Sand agitators	Six jets, 2½″ diam.	Six vert. cutters.	9 jets, 2½″ diam.	Horizontal cutters.	10 jets, 2″ diam.	Oscillating rake.
Engines, kind	Compound non-condensing.	Cross-compnd non-condensing.	Compnd condensing.	Two simple.	Vertical compd non-c'nd'sng.	Two simple.
" size	...	14½″—29″ × 18″	12″—22″ × 14″	12¼″ × 15″	12″—22″ × 12″	Each 12″ × 16″
" revolutions per minute	190	120	160	...	200	180
Cutters, revolutions per minute	...	12	...	5	...	60 double strokes.
Engines, horse-power	125	...	200	...	150	80
Jet pumps	Centrifugal.	...	Centrifugal.	...	Centrifugal.	...
Suction and discharge, diameter	10″	...	18″	...	18″ and 15″	...
Suction head	6	...	7	...	5	...
Delivery head	20′	...	28′	...	30′	...
Boilers—Number	4	4	6	4	6	6
Boilers—Kind	Mississippi River.	Heine 375 HP.	Mississippi River.	Heine 250 HP.	Mississippi River.	Mississippi River
Boilers—Size	42″ × 28″	...	48″ × 28″ Five 11″ flues.	...	48″ × 28″ Three 11″ & Two 13″ flues.	48″ × 28″ Three 11″ & Two 13″ flues.
Pressure used	135 lbs.	165 lbs.	140 lbs.	155 lbs.	150 lbs.	150 lbs.
Coal used per 24 hours	500 bush.	2,088 bush.	400 bush.	1,200 bush.	...	...
	$98.70	$221.63	$100.51	$111.76	.....	.....

Total cost of running dredge per day .....Cost of steam tender per day, $37.00. Cost of pile sinker per day, $13.00. ....

frame located over the forward end of the suction well. A straining frame is provided so that when the suction is lowered to a suitable depth it can be locked; it thus relieves the tackle of the weight, and maintains the suction at a constant depth. Each part of the suction head is 10 ft. long, making the suction 20 ft. wide over all.

The "Epsilon" suction head has a pressure chamber on the under side at the front end connecting with the jet pump. Ten 3-in. jet nozzles are screwed into the front side of this pressure chamber and serve to loosen and stir up the sand and induce the flow of material to the suction.

The discharge pipe passes straight aft from the pump between two central keelsons, and rests on the floor beams for a distance of about 52 ft. From this point it rises gradually for a distance of 22 ft. until the center of the pipe is 4 ft. above the bottom of the boat. Then it runs horizontally straight out through the stern, projecting far enough to couple on the floating pipe line. The pipe is flattened out near the pump casing so as to depress it below the water-line and thus facilitate priming, which is done by using a steam syphon at the top of the casing. The floating discharge pipe is similar to those previously described, except that greated buoyancy is provided, and the shape of the float is somewhat flatter.

A velocimeter is provided for showing the velocity of flow in the discharge pipe. This consists of two vertical tubes which pierce the discharge pipe. They are set in the vertical plane passing through a longitudinal axis of the discharge pipe. About 5 ins. below the upper inner surface of the pipe, ¼-in. tubes, 6 ins. long, are inserted horizontally; the one nearest the pump being open toward the pump to receive the pressure of flow and the other turned in the opposite direction. The upper ends of the vertical tubes connect with glass tubes attached to suitable scales. The difference in the height of the columns of water in the two tubes, when water is flowing through the discharge pipe, gives results from which the velocity of flow can be deduced.

Weighing apparatus, designed to show the percentage of solid matter passing through the discharge pipe, is also provided. To accomplish this, a suitable length of the pipe is connected at each end by rubber thimbles, which leaves the joints flexible. One end of this pipe is then supported by a weighing apparatus properly counterbalanced. An indicator is located where it can be readily seen by the engineer. The pointer is set so that it reads zero on the dial when water only is pumped. When sand is pumped the pointer will show on the dial the weight of the same at any moment, and consequently the percentage of solid matter.

The total approximate weight of each dredge is 1,057,118 lbs.; weight of floating pipe line, 325,000 lbs.

The efficiency tests of these dredges were begun about the middle of January. Owing to delays occasioned by high water and some minor modifications that were required, the capacity tests were delayed until the latter part of March, 1898.

The specifications and plans of all the dredges of the Mississippi River Commission have been prepared under the direction and subject to the approval of the Committee on Dredges, consisting of Major Thomas H. Handbury, Corps of Engineers, U. S. A.; Henry Flad, M. Am. Soc. C. E., and B. M. Harrod, Past-President, Am. Soc. C. E. The dredges "Gamma," "Delta," "Epsilon" and "Zeta" were constructed under the direction of Capt. H. E. Waterman, Corps of Engineers, U. S. A.

Table No. 1 gives the leading features of these five dredges, working below Cairo, Ill. Table No. 2 gives some particulars of the tests, showing the minimum and maximum capacities of these dredges:

Another dredge has been designed for work on the river below Cairo, and the contract for its construction will be let during the present year. This will be a single-pump dredge, similar in form to the "Epsilon," but will be provided with side wheels and propelling machinery.

Two dredges for use on the Mississippi River between the Missouri and Ohio Rivers are now under construction, and are practically completed. They were designed and constructed under the direction of Major Thomas H. Handbury.* They will be ready for use during the next low-water season. It is expected that a navigable channel 6 ft. deep can be maintained with these dredges, aided by the temporary jetties and the jet dredge.

The hulls of these dredges are of steel, 160 ft. long and 40 ft. wide, with 6½ ft. depth of hold. Their working draft will be about 3½ ft.

*These dredges were described and illustrated in our issue of July 22, 1897.

Each dredge is provided with two centrifugal pumps with a single 20-in. suction in the axis of the pump, discharging from the lower side of the casing. The discharge at the pump is 20 ins. diameter, but is expanded to 24 ins. at the discharge pipe. The casing of the pump is 48 ins. in diameter and 28 ins. across the inside.

Each pump is operated by a direct-connected, horizontal, compound, non-condensing engine, designed to run 200 revolutions per minute and develop 300-HP. at a boiler pressure of 140 lbs. This speed is to be regarded as the average work of the engine, and is expected to maintain through the suction and discharge pipes the velocity necessary to carry at least 20% of sand and 80% of water under a maximum head of 30 ft.

A jet pump is provided with each main pump, which serves to loosen up the material at the end of the suction and thus facilitate its passage into the suction pipe. The jet pump has two high-pressure cylinders 8 ins. in diameter, two low-pressure cylinders 12 ins. in diameter, and two water plungers 12 ins. in diameter; all having 10-in. stroke. The capacity of the pump is 1,200 gallons per minute against a water pressure of 65 lbs. when running compound under a steam pressure of 150 lbs. These pumps discharge through 8-in. pipes terminating in three bronze nozzles 1½ ins. in diameter, their extremities radiating to a distance of about 30 ins. apart and just beneath the suction of the main pump.

Steam is supplied by six boilers of the Mississippi River steamboat type.

Dredge "Ram."—In the fall of 1893 the dredge "Ram" was completed by the Bucyrus Steam Shovel & Dredge Co., for use in keeping open the channel from the Mississippi River into the Red and Atchafalaya Rivers. It was built under the direction of Capt. John Millis, Corps of Engineers, U. S. A., and cost $69,500. The capacity is about 300 cu. yds. of mud per hour, delivered through 300 ft. of pipe. It is provided with propelling machinery such as commonly used on stern-wheel steamboats. The hull is 95 ft. long, 27 ft. beam and 7½ ft. deep. The dredging pump is an Edwards centrifugal, with 15-in. suction and discharge. The pump is run through a belt connection by a horizontal, compound-condensing engine, with cylinders 14½ and 26 ins. diameter, and 20-in. stroke.

This dredge can work in any depth up to 30 ft. It is so arranged that material can be discharged on either side at will. A vertical anchor spud is provided in the stern of the boat, on which it swings by means of kedge anchors laid out from either side of the bow and maneuvred by winding drums. In this way a wide cut can be made by swinging the cutters from side to side.

The cutter and suction is supported by an A-frame, the inner legs of which are pivoted to the sides of the bow. The frame is raised or lowered with wire rope tackle attached at the upper end to suitable shears and operated by winding drums. The cutter is a conical steel casting with eight steel blades forming a cutter 24 ins. in diameter at the end and 54 ins. in diameter at the base. This cutter is at the outer extremity of a 5-in. steel shaft, which is revolved by gear wheels at the bow of the boat, and operated by a sprocket wheel and chain. The suction proper starts at the base of the cutter.

This boat has been quite successful from the start. During the low-water season of 1894 she dredged 205,000 cu. yds. of material at a cost of a trifle over 4½ cts. per yard. The material was largely mud and clay. The material is generally delivered through about 50 ft. of pipe suspended from a derrick and attached to the boat. This boat has also been used with considerable success in building levees. It is estimated that under favorable conditions a levee 10 ft. high can be built at a cost of about 6 cts. per cu. yd.

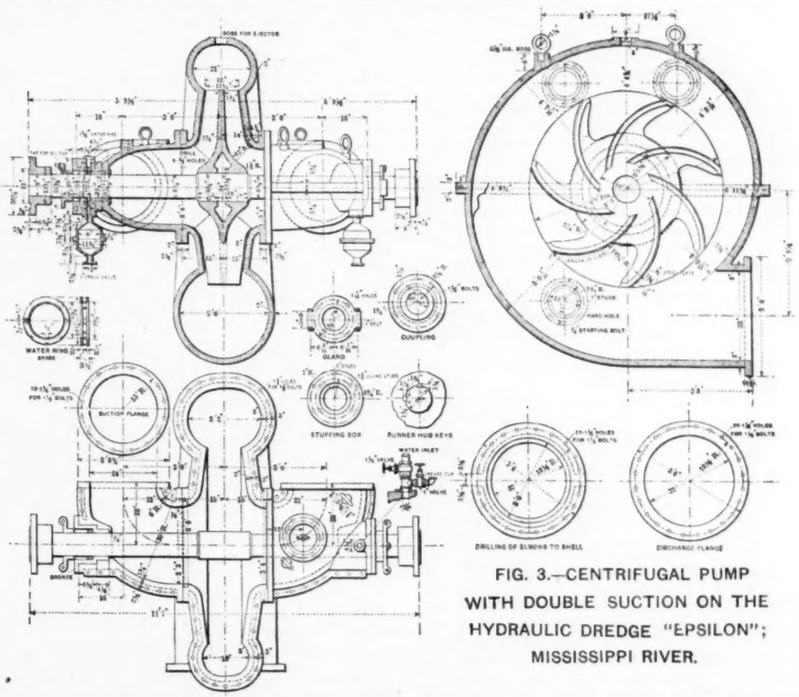


FIG. 3.—CENTRIFUGAL PUMP WITH DOUBLE SUCTION ON THE HYDRAULIC DREDGE "EPSILON"; MISSISSIPPI RIVER.

Menge Dredges.—In 1888 two dredges of the elevator type were procured, one for use in Vicksburg harbor and one for the mouth of the Red River. These were called the "Menge" and the "Pah-Ute."

In actual work the "Menge" has dredged 4,000 cu. yds. in 10 working hours. This dredge cost about $18,000. The "Pah-Ute" has about half the above capacity, and cost $10,000. These dredges, as generally equipped, deliver the dredged material in dump scows, which are towed to the desired point and dumped. In some favorable situations the material is delivered through sluice boxes supported on barges. These dredges, if properly constructed, are very successful when operated in soft material.

Dredge "Bayley."—This was built by Carroll & Co., of Pittsburg, for use in South Pass. It arrived at Port Eads in the fall of 1877. It is constructed of iron throughout. The hull is about 200 ft. long over all, 32 ft. wide, and 10 ft. depth of hold. With fuel on board, it draws about 5 ft. of water. It is self-propelling by means of side-wheels 25 ft. in diameter, with buckets 11 ft. long. These wheels are operated by two engines with cylinders 21 × 84 ins.

This dredge has a centrifugal pump of the Andrews' cataract pattern, with a runner 6 ft. in diameter and 3 ft. wide, mounted on an 8-in. steel shaft. It is operated by two independent condensing engines, placed forward of the pump, having cylinders 24 × 20 ins. The wrought-iron suction pipe is 27 ins. in diameter. The suction is supported on a flat plate resting on the sand to prevent the scraper from cutting too deep. This scraper takes in a slice of sand about 8 ins. deep and 4 ft. wide. A stream of water of about half the above depth and the same width enters the suction at the same time.

The movable part of the suction, when in operation, is 26 ft. of water, stands at an angle of about 35°. When not in use it is lifted above water, under the extension of the main deck, the end projecting about 15 ft. aft of the stern post. The discharge pipe is 30 ins. in

TABLE No. 2.—Summary of Tests of Mississippi River Dredges.* (Showing minimum and maximum capacity.)

	"Alpha."		"Beta."		"Gamma."		"Delta."		"Epsilon"		"Zeta."	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Sand pumped, cu. yds. per hr.	405	905	868	7798	1130	2595	928	3212	1713	3102	1071	1872
Percentage of sand‡	6.93	12.45	2.6	36.4	15.8	29.0	7.4	25.5	13.6	25.8	8.1	14.8
Velocity, discharge, ft. per sec.	8.94	11.10	20.8	13.5	8.48	10.64	14.96	15.01	16.9	16.4	17.8	17
Material pumped, cu. ft. per sec.	43.85	54.49	247	160	53.46	67.07	94.35	94.65	94.48	90.16	99.31	94.92
Efficiency, per cent.	62.62	54.85	65.8	65.2	59.5	74.2	74.4	..	83.6	78.8	87.6	78.4
Revs. of main pump, per min.	125	153	150	154	174	169	150	149	181	182	181	182
Steam pressure, lbs.	130	118	177	176	152	125	156	156	155	165	146	145
I. HP. of main eng. and pump.	274	319	2561	2892	486	508	997	..	712	801	661	718
Forward movement, ft. per min.	1.26	4.26	7.5	5	2.2	6.6	2.7	7	4.4	9.4	3.2	4.8
Depth of suction	7.3	10.56	14.6	17.5	12.0	11.0	14.2	15	15	14	14	14
Depth of water	6 to 7	7 to 8	8.3	9.2	4.7	5.2	8.3	7	8.5	7	8	7.5

*This table is compiled from the various tables in Mr. Ockerson's paper.
‡The sand weighs about 100 lbs. per cu. ft. when dry; and has about 35% of voids when wet.

diameter, and is arranged so that the spoil can be deposited in the spoil bins on board, or delivered on either side of the boat through pipes swung from derricks.

The four spoil bins stand forward of the engines. They are 60 ft. long, 19 ft. wide and about 20 ft. deep, and have a capacity of about 512 cu. yds. of dredged material. These tanks are filled in about 7 minutes, when the suction is raised and the boat proceeds to the dumping ground. Two-thirds of the available time is occupied in unloading. Overflow gates are provided so as to allow the water to escape while the sand settles to the bottom, thus insuring a greater load of solid matter. In a working day of 13 hours the average amount of solid matter removed is 1,300 cu. yds. The tanks are divided into compartments, each of which terminates in a hopper having a 4-ft. opening through the bottom of the hull. These openings are closed by valves operated by hydraulic jacks with a capacity of about 12½ tons. The sand is washed out of the tanks by means of two jets in each hopper.

The capacity of the dredge when delivering the material as described is about 350 cu. yds. per hour. If the material is simply delivered overboard, the capacity is about 1,000 cu. yds. per hour. When dredging, the boat moves down stream, with the suction lowered, at the rate of about 2½ miles per hour.

This dredge cost about $150,000. It was designed by Jas. B. Eads, M. Am. Soc. C. E., for the special purpose of working in deep rough water with strong currents.* This boat is now over twenty years old, but is still serviceable.

The foregoing descriptions cover a fleet of eight hydraulic dredges of large capacity and five other dredges, all of which are now available for use in improving the low-water navigation of the Mississippi River. The "Alpha" has been operated for three seasons, the "Beta" for two seasons, and the "Gamma" and "Delta" for one season. They have all demonstrated the practicability of moving economically immense quantities of material in a short space of time. They have also shown that good navigable channels can be opened through the reefs that obstruct navigation.

As far as the machines themselves are concerned, they seem to meet the requirements fully. The value of these dredges as aids to navigation depends far more on the proper location and direction of the cuts to be made than on the efficiency of the machinery. Experience may show that in some cases the dredges can be made more efficient by filling side chutes and thus throwing the water into one channel, rather than attempting to enlarge one of the channels by dredging out the material. It may also be found desirable in some cases to discharge the material at the sides of the proposed channel rather than to deliver it at a distance through long discharge pipes.

The volume of material rolled along the bottom is so great as to far outweigh the greatest possible capacity of any dredge. To those who are not familiar with this phenomenon it will seem incredible that a dredge with a capacity of over 1,000 cu. yds. per hour may be operated for days and leave scarcely a trace of the cut. Or, on the other hand, if the cut has been so located as to meet the requirements of the current, a channel will be scoured out and an amount of material removed which would probably exceed the capacity of the dredge many times. It is by no means certain that the channel will always follow the line of the cuts. It sometimes happens that after some days of diligent dredging, a channel develops without assistance on a line quite remote from the dredged cuts.

Whatever is done during one low-water season is generally obliterated by the succeeding high-water. The successful location of a cut during one low-water season does not necessarily imply that a similar location during the following season will give like results. In fact, a new problem is presented by each bar every season.

In a stream of this character it is, of course, extremely difficult to determine in a particular case justs what share of the channel should be credited to the dredging and what proportion to natural causes. Enough bars have been dredged, however, to fully demonstrate that the dredging at least induces the scour which eventually results in a wide and deep channel.

During the low-water season of 1897, four dredges were at work on the bars below Cairo, and the cost of operating them was as follows:

Labor	$26,704.53
Fuel	13,474.23
Subsistence	7,586.99
Lubricants	970.79
Lighting supplies	215.05
Miscellaneous supplies	1,527.79
Office supplies	145.10
Hire of tow boats for moving plant	10,115.50
Preparation and moving into field	3,269.44
Moving to winter quarters at end of season	4,637.03
Cost of inspection and supply boat	10,554.75
Cost of operating two survey boats	8,674.10
Total	$87,875.30

There was a conspicuous sand bar at Lazelles, some 82 miles below Cairo. When the survey of this bar was made, just before dredging, the distance from the 9-ft. depth in the upper pool to the same depth in the lower pool was 1,400 ft. At that time the amount of excavation required to make a 9-ft. channel 250 ft. wide at the datum stage was 61,000 cu. yds. The dredge "Gamma" was at work on this bar ten days, and the actual dredging time was 178 hours. Taking the capacity of the dredge at 800 cu. yds. per hour gives the total amount dredged as 142,400 cu. yds. Thirty-one days after the dredging was completed there was a 10-ft. channel clear through the reef, except for a distane of about 225 ft., where the depth was only 8 ft.; 76 days after the dredging was completed the channel was found to be 350 ft. wide at the narrowest point, over 1,000 ft. wide for more than nine-tenths of the length, and with a least depth of 9 ft., and an average depth of 11 ft.

At President's Island, just below Memphis, the dredge 'Delta" was employed in opening a channel through a reef which was causing much trouble to navigation. In the bed of the river in this locality there is a considerable quantity of conglomerate rock and lignite to be found. The mechanical agitators of the "Delta" were, therefore, put to a very severe test. One solid piece 3½ × 4½ ft. was caught in the cutters. It had to be broken into small pieces to dispose of it. When work began there was barely a 5-ft. navigable channel across this bar. After 15 days' work, during which period much time was lost in clearing the cutters of debris, leaving only 80 hours actual dredging time, a 9-ft. channel 100 ft. wide and 1,300 ft. long was completed. This channel remained intact throughout the season, although a wider channel broke through the bar lower down.

These bars do not all develop at the same time, and they do not necessarily develop at the same places during successive seasons. There are, however, certain general localities that have long been recognized by steamboatmen as liable to develop bad navigation during any low-water season. Now and then, even these places pass through a season without developing any serious obstructions, and at such times dredging below Cairo will be unnecessary. Seasons having good navigation throughout are, however, not frequent.

Dredging operations will, in the main, be confined to the same general localities from year to year, although wrecks, snags and bank erosions may occasionally develop new bars that will require dredging.

The season of 1895 was one of extraordinary low water. At one time during that season there were 57 crossings between St. Louis and Cairo, where the water was 6 ft. or less in depth. During ordinary seasons about as much dredging would be required between St. Louis and Cairo to secure a 9-ft. channel 250 ft. wide as is required below Cairo for a similiar channel. The supply of water above Cairo at extreme low stages is too limited to readily admit of 9-ft. channel depths. The requirements of river traffic on this reach would be satisfied fairly well by 7 or 8 ft., and it is doubtful whether these depths can be materially exceeded by means of dredges or other temporary devices at an expense justified by the value of the results obtained.

It is evident from the foregoing that the problem of keeping navigation open in the Mississippi River during the low-water season is very far from being a simple one. The magnitude of the plant described is sufficient evidence that strenuous efforts are being made to "improve and give safety and ease to the navigation" of the river, and the experience gained thus far justifies the belief that these efforts will be successful.

The writer is indebted to Gen. John M. Wilson, Chief of Engineers, U. S. A., M. Am. Soc. C. E., to Maj. Thomas H. Handbury, Capt. H. E. Waterman and other officers of the Engineering Corps for free access to records and drawings. He is also indebted to his associates, engaged in the improvement of the river, for valuable assistance in the preparation of drawings and tabulated data.

*See "The Mississippi Jetties," by E. L. Corthell, M. Am. Soc. C. E.

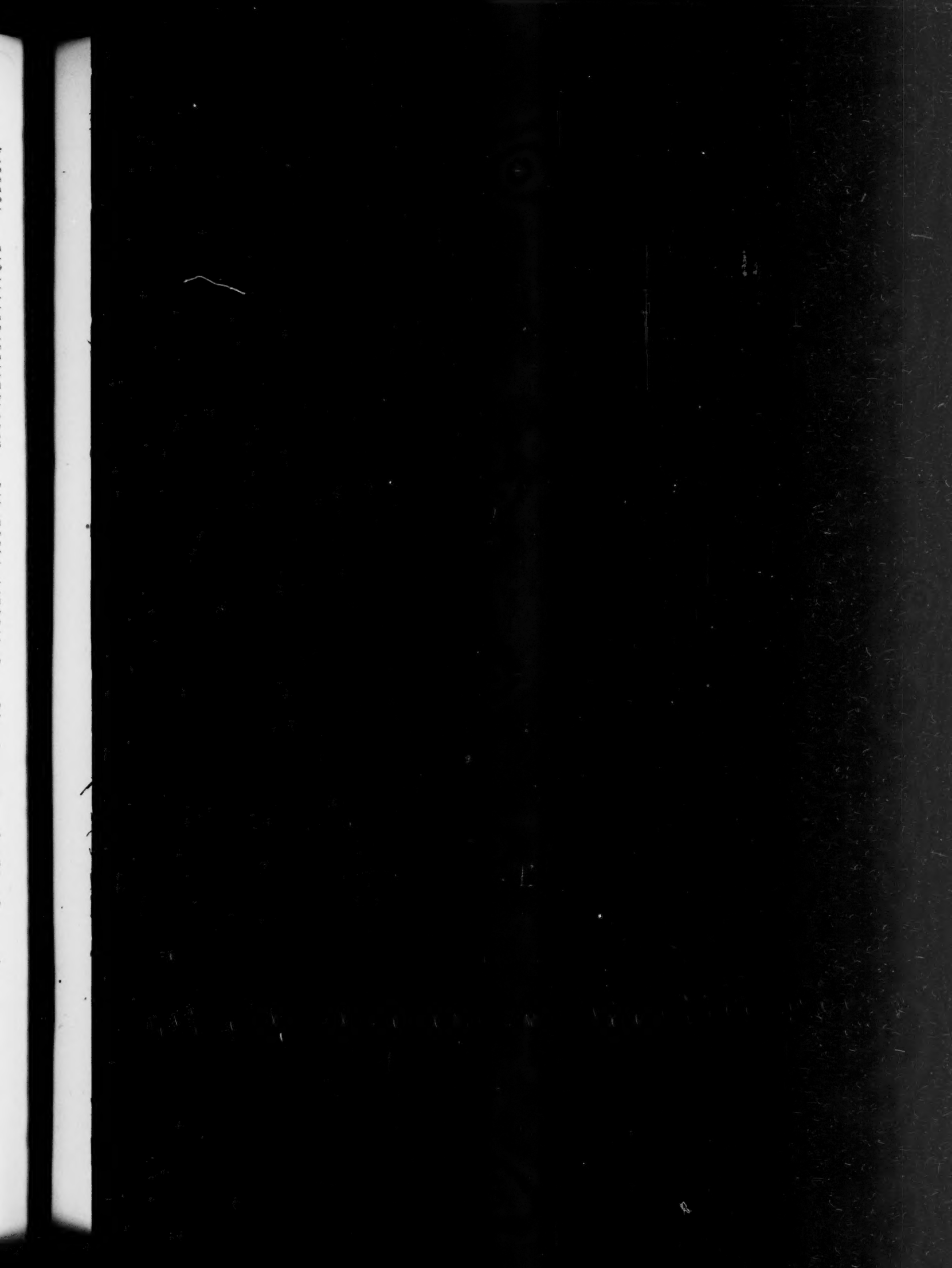
THE RAILWAYS OF NEW SOUTH WALES, which are owned and operated by the government, aggregated 2,691 miles in length on June 30, 1898, or 52 miles more than in 1897. Several light or pioneer railways have been built and have given satisfactory results. The traffic aggregated 8,340,338 train-miles, with gross and net earnings of $1.81 and 84 cts per train-mile. The total earnings were $15,133,740, and the balance after paying operating expenses was $7,060,715, the operating expenses being 53.34% of the gross revenue. The freight traffic aggregated 4,561,943 tons, with an average haul of 56.63 miles per ton, and earnings of 2.76 cts. per ton per mile. Improvements of grades and curves are being made, the work being done by the Railway Commissioners and not by contract. The Commissioners also control and operate 65 miles of street railway, operated by steam, cable and electricity.

AN ELECTRIC RAILWAY TRAIN SERVICE has been put into operation between Berlin and Zehlendorf, 7.5 miles distant. The train is made up on nine carriages of the type used on the Berlin elevated railway, weighing 210 metric tons. The carriages at the head and rear of the train are equipped with electric motors, and one or the other hauls the train, according to the direction of motion. All shifting of cars at terminal stations is thus avoided. The run occupies 27 minutes including four stops, and there are 15 trains a day each way. Each motor car is equipped with two electric motors of 100 HP., mounted over the two end axles. The two motor cars are so connected, electrically, that both may be used in case of need, and the four motors may be employed in braking. Besides the electric brakes on the motors, all the carriages in the train are equipped with electro-magnetic and Westinghouse brakes. The current is distributed by the third-rail system at a tension of 550 to 600 volts.

THE ELECTRIC TRAMWAYS OF SWITZERLAND, on July 1, 1898, had a total length of 69 miles in actual operation, and 64 miles under construction; concessions for 200 miles more had been granted to different companies. Water power is usually available for generating the current. The usual gage is one meter. The overhead system is generally used with copper wires 6 to 9 mm. diameter, elevated from 16 to 20 ft. above the road surface. In the establishment of new lines alternating currents are generally employed, with a maximum tension of 750 volts, as fixed by law; when continuous currents are used the maximum tension is 1,000 volts. The motor cars weigh from 9,900 to 16,500 lbs. and carry from 22 to 45 passengers. Handbrakes, working on 4 or 8 shoes, are usually applied to the wheels. For the tramways of Fribourg and Lausanne, where grades of 9.2 to 11.3% are met with, the heaviest grades on simple friction railways in Europe, very strong safety brakes are employed, in the form of spurs that may be forced into timbers running parallel to the rails. Speed on the Swiss tramways is fixed by law, at a limit of 7.5 miles per hour in cities and towns, and 15.5 miles in the open country.

A NEW TIMBER DAM AND POWER PLANT will be constructed by the Twin City Rapid Transit Co., of Minneapolis, Minn., at a point about 3½ miles north of the city limits of Minneapolis, Minn. The dam will be 1,198 ft. long and will cross the Mississippi River, furnishing a head of water of 20 ft. Its total cost ready for the power house and machinery, is estimated at $308,079. The power house contemplated provides for nine flumes, each holding four 42-in. turbines on one shaft, or 36 turbines capable of developing under a 20-ft. head a nominal power of 10,145 HP. This power house and the machinery, including about $75,000 for flowage rights, will bring the total cost of the improvement up to $525,000. The bulk of the power—all but 3,000 HP. or 4,000 HP., which will be sold—will be used by the rapid transit company, which will thus be able to abandon all its steam plants. The preliminary estimates and plans for the timber dam have been made by Mr. E. T. Abbott, Civil Engineer, of Minneapolis, Minn., and a beginning on the construction will probably be made this winter.

THE MOTOR USED ON THE ELECTRIC CABS in use in New York city are 4-pole, 2-HP. machines operating on 80 volts, and 23 amperes at a speed of 800 r. p. m. They are of the enclosed circular type with cast steel fields and laminated poles. The armatures have 41 slots, and both armature and field coils are machine wound. The fields are connected two in series, and these pairs in parallel, making four field wires and two armature wires which pass through the field frame and connect with the controller. At full load (23 amperes) the efficiency is 83%; at ¾-load 84%; at 1¼-load 79%. At full-load the motor will operate for two hours with a maximum temperature rise of only 40° C.

THE SWISS TELEGRAPH BUSINESS is a branch of the Post, Telegraph and Railway Department, and any post-office will receive or deliver prepaid telegrams. At the end of 1896 the telegraph lines represented a length of 4,865 miles, and there were 252 telephone stations, with 6,150 miles of wire and 25,090 subscribers. Snowfall is very troublesome, and 35% of the wires are now underground. In 1896 the official balance-sheet showed, for telegraphs, $562,780 received and $519,520 expended; for telephones, the statement was $866,700 received and $869,680 expended. On Jan. 1, 1896, the telephone rates were reduced, with an increase of 4,555 subscribers; but the annual income was decreased $56,870. The unfavorable weather of 1896 also affected the summer business in telegrams; in the extent of 3.83% in internal, 0.04% in international and 5% in through messages.

MAGNETIC DEFLECTION OF IRON PLUMB-BOBS, in shaft work, is noted by Mr. O. Brathuhn in an article on underground surveying in the "Berg und Hüttenmannische Zeitung" for 1898. He notes that in plumbing a shaft 390 ft. deep with an iron plumb-bob, he found a considerable error. The explanation lay in a cross-cut from the shaft in which a large number of spare rails had been stored with one end of the pile very close to the plumbline. He says that by the induced magnetism of the rails the plumbline was drawn from its perpendicular position to such an extent that the bottom of two lines were 7.5 mm. further apart than the tops of the same lines, and the line connecting the plumb-lines at the points of suspension formed an angle of 6' with that at the bottom of the shaft. The trouble was corrected by using brass plumb-bobs.